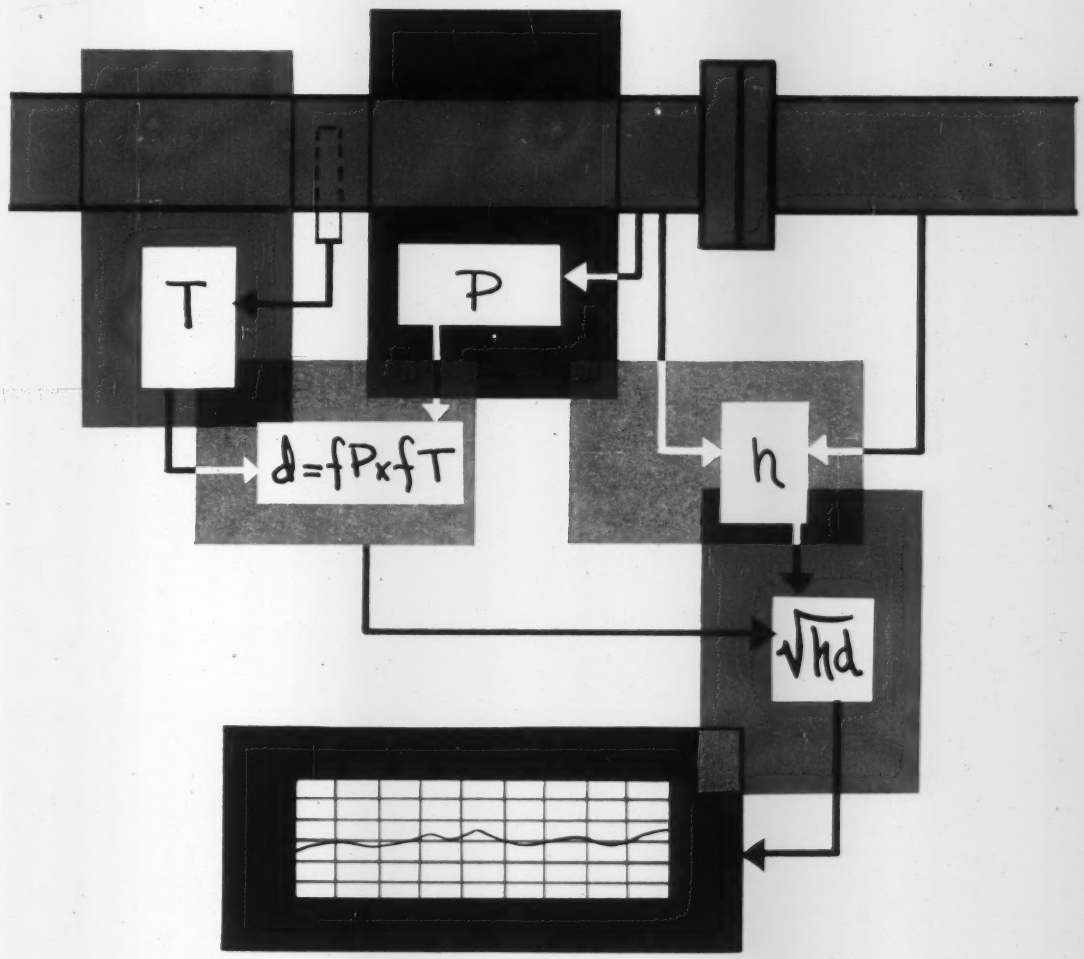
INSTRUMENTS AND CONTROL SYSTEMS

INCLUDING: INSTRUMENT MANUFACTURING • JOURNAL OF THE SOMA • SIMULATION COUNCIL NEWSLETTER



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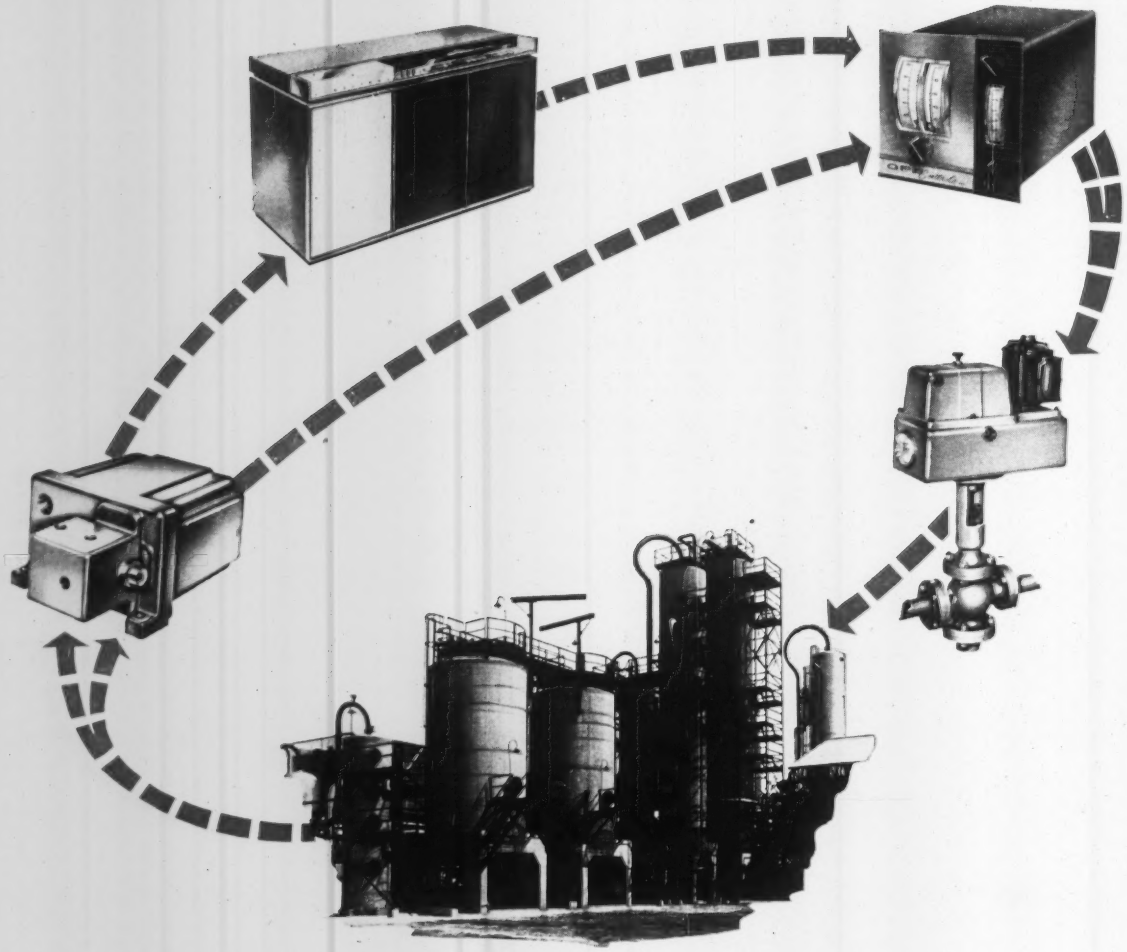
THIS PRINTING: 30,500



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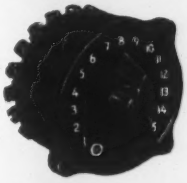

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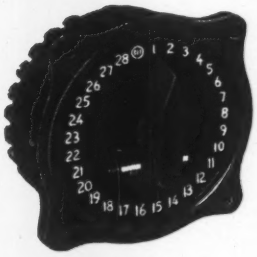

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AUGUST 1959

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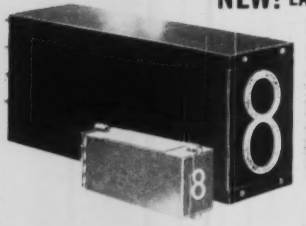

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INSTRUMENTS AND CONTROL SYSTEMS

VOL. 32 No. 8 AUGUST, 1959

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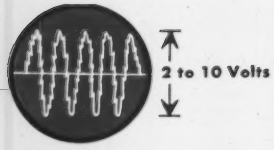

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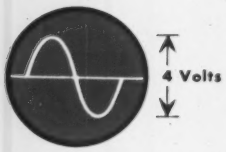

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Honeywell

H HONEYWELL *First in Control*

CIRCLE 6 ON READER-SERVICE CARD

to the editor

Editor, I&CS:

On page 494 of the April issue of *Instruments and Control Systems* there is a discussion of well-type manometers.

I should like to point out that the idea of adjusting the diameter of the well so that a true linear scale can be used in this type of manometer has been patented . . . my U. S., Patent #2,679,759.

Dr. Roger Gilmont
President and
Technical Director
Manostat Corp.
New York, N. Y.

Editor, I&CS:

May we readers of your Journal ask you to go one step further in your efforts in upgrading the high-school science curriculum? With so much useful effort over such a long period of time, we readers of Southern Connecticut would like you to act as a clearing house for such data.

I enclose herewith a first contribution to that file (the Second Annual Science Fair at Greenwich High School); it originates with the Science Education Association of Southwestern Connecticut which has as one of its important sponsors the Connecticut Society of Professional Engineers Inc, Southwestern Chapter.

To my knowledge no one is presently acting as such a clearing house.

Wm. H. Offenhauser, Jr.
New Canaan, Connecticut

Such a clearing house could be valuable. The National Science Foundation, the Joint Engineer's Council for Professional Development, or the Foundation for Instrument Education and Research have funds for education activities.

Editor, I&CS:

I am pleased that *Instruments and Control Systems* dedicated an issue to a survey of digital printers. I believe this is the first time that any magazine has done this . . . You have the hearty approval of all the members of the Electronics Division of Clary Corporation.

W. R. Beall
Clary Corporation
San Gabriel, Calif.

Editor, I&CS:

I am in the process of compiling such terms and definitions as have been published on the subjects of automation and computers. I would be grateful if you could advise where I might obtain such information.

James L. Miller
General Electric Co.
Waynesboro, Virginia

The following organizations have developed terminology:
1. Communications of the Association for Computing Machinery, 5800 N. Marvine Street, Philadelphia 41.
2. The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.
3. The American Institute of Electrical Engineers, 33 West 39th Street, New York, N. Y. (electrical and nuclear terminology).
4. Data Processing Digest, 1140 South Robertson Boulevard, Los Angeles 35, Calif.

There have been many dictionaries of technical definitions which you should consult. One is published by the Technical Society, 848 East 58th Street, Chicago 37, Ill. Our definition of automation is "use of devices —mechanical, pneumatic, hydraulic, electrical and electronic—to make automatic decisions or efforts."

Editor, I&CS:

This Company is instituting a training course covering the general field of industrial electronics to be presented on the technician-assembler level. We have been following your articles advocating technical education at the lower levels with great interest, and hope that you may be able to be of assistance to us. We are searching for a textbook to be used with the course mentioned above. We plan on setting up this course as a general survey of the entire field of industrial electronics commencing with ohms law and ending in such fields as traveling wave tubes, etc. The course must be presented in such a manner as to be understood by people with as little as one year of high school education.

N. C. Seiler
Sperry Microwave
Electronics Co.
Clearwater, Florida

The book ELECTRONIC CIRCUITRY FOR INSTRUMENTS & EQUIPMENT, by M. Aronson, Instruments Publishing Co., $2.00 is widely used for exactly this level.

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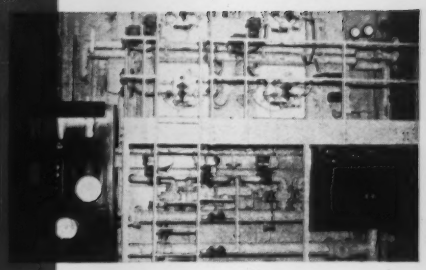
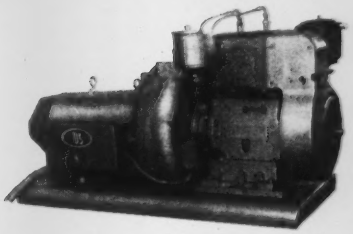


MICRO-POWER



In plants like Douglas Aircraft Company, Inc., in Tulsa, Oklahoma, where a continual supply of steam is vital to production processes, every precaution must be taken to assure against the hazards of boiler flame-out. To safely regulate the shutting down of its burners in the event of flame-out, the company utilizes highly sensitive electric controls. Since these flame failure controls *are* electric and must depend on a constant, unwavering power supply for successful operation, a further precaution is taken . . . MICRO-POWER.

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The Douglas Aircraft Company, Inc., Tulsa Division, "Micro-Power" application is just one of a wide range of uses for this versatile standby power unit. For complete product and application information, call or write . . .

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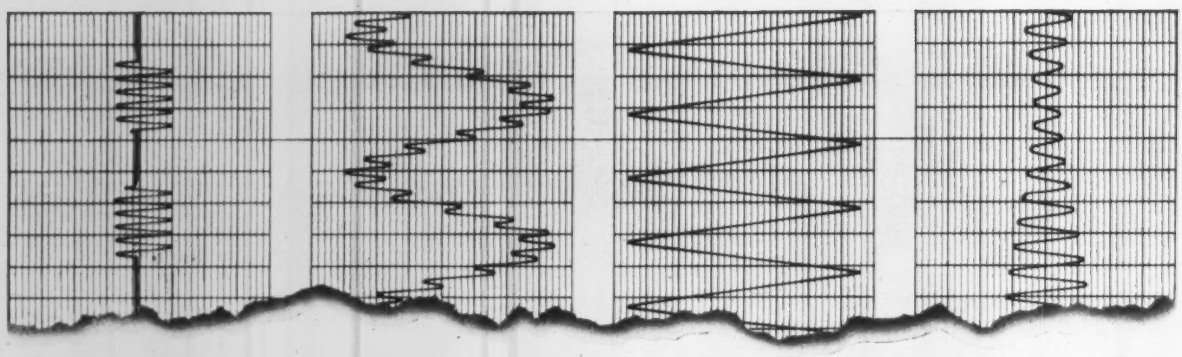

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LETTERS—CONTINUED

Editor, I&A:

Reference: *I&A* July '58, Inquiry A-324.

The following notes relate to the problem, outlined in the above reference, of using calipers to measure a five-foot dimension with an accuracy of 50 millionths inch. The technique outlined below, though not to my knowledge available commercially, uses well established microwave techniques. The method is essentially to use a resonant cavity to stabilize the frequency of a klystron oscillator, let the resonant frequency of the cavity change in accordance with the change of roller dimensions, and measure the resulting change of frequency of the klystron by comparison with the output of a crystal oscillator and frequency multiplier chain. This method is based on the klystron stabilization scheme first described by R. V. Pound in the *Review of Scientific Instruments*, vol. 17, page 490, 1946.

A klystron operating at 10,000 megacycles per second can be stabilized to better than 100 cycles per second, or one part in 10^9, according to Pound. A typical right circular cylindrical cavity at 10,000 mc/s will tune at the rate of 10 mc/s for 0.001" motion of an end plate. A motion of 0.05 mils would thus produce a frequency shift of 50 kc/s. A thermally controlled quartz crystal at 10 mc/s has a stability of one part in 10^7 or better. The 10 mc/s signal can be multiplied in steps of three to 810 mc/s, from which a semiconductor diode multiplier will give a twelft'h harmonic at 9720. This is a total multiplication of almost 1000, so the accuracy at this frequency will be about one kc/s. The motion of the cavity end plate can thus be measured to 10 millionths of an inch. A klystron can be tuned electronically over a range of 20 to 50 mc/s, so it will follow plus and minus one mil motion of the cavity. A total range of an inch or more can be obtained by providing markers from the multiplier chain. An alternative method for extending the range would be to use a micrometer screw to set the position of the cavity in increments of one mil.

Application of this technique would require mounting the cavity, the klystron, and some microwave components on the calipers. The total volume would be about six cubic inches and the weight perhaps five pounds. The electronic equipment, which could be mounted at a convenient distance, would include an oscillator, an amplifier, and a phase sensitive

WHICH VALVE IS OPEN?

They both are . . . but only the Hydromatics ***FLO•BALL 715***, on the right, shows its position at a glance! A fast **quarter** turn moves it from open to closed position—instant action at flow pressures up to 3,000 psi with just 4 inch-pound torque. The ***FLO•BALL***'s exclusive straight-thru design has 100% flow efficiency—more than double the flow of needle valves!

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Write today for a complete catalog describing this valve and others for corrosive and cryogenic media. Also special designs for throttling flow control.

The *FLO•BALL* costs no more than old fashioned screw-type valves!

FLO-BALL

Exceptional engineering employment opportunities—write today!

Hydromatics, Inc.

LIVINGSTON, N. J. • WYMAN 2-4900 • TWX=LIVINGSTON, N. J. 120

Copyright 1959 Hydromatics, Inc.

CIRCLE 9 ON READER-SERVICE CARD

There's No End To It!

A Fenwal Continuous-Line Over-Heat Detector provides maximum "hot spot" protection

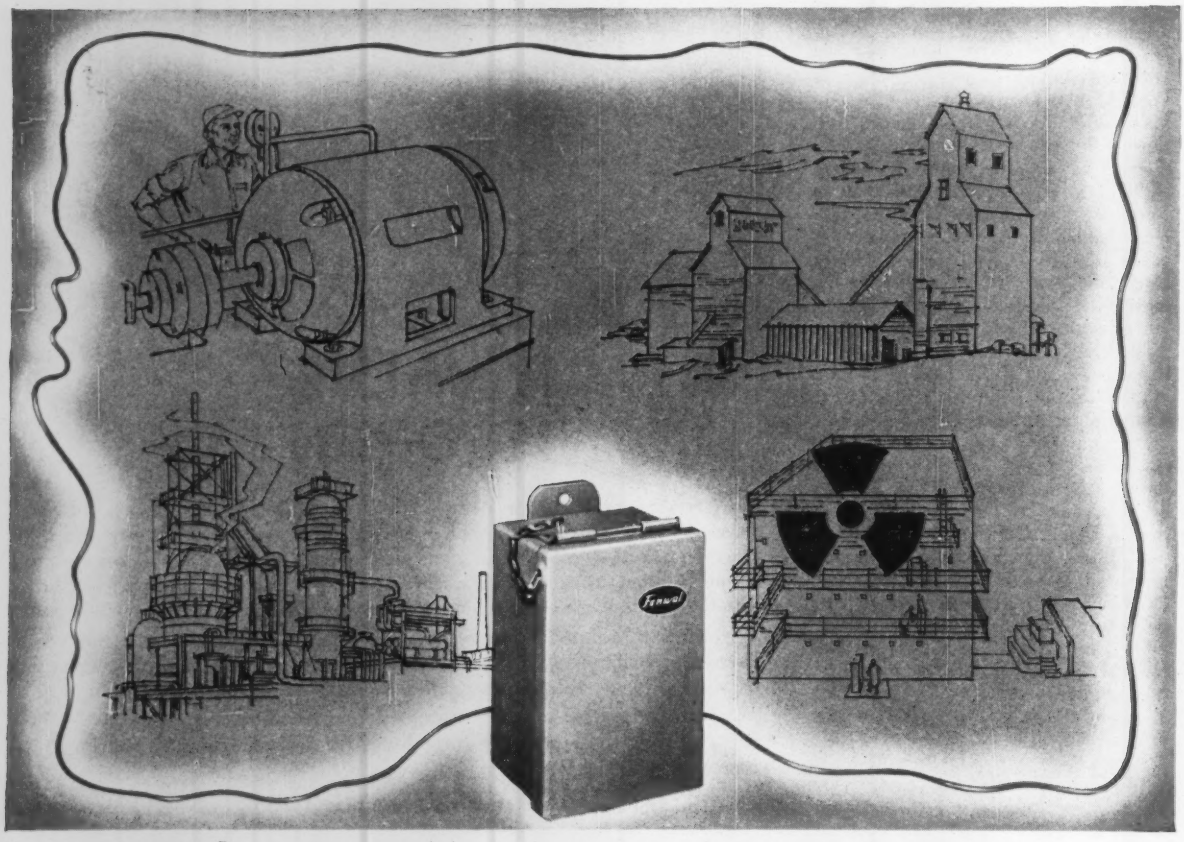
Hot as blazes, or just simmering, *any* undesirable temperature is quickly spotted by a Fenwal Over-Heat Detector. No individual sensors with resultant "dead spots." It's a discrete-sensing (non-averaging) system. Heat impinging at any point on sensing line triggers the alarm. *That's complete coverage!*

Line mounts easily — forms continuous loop back to compact control unit. Separate, connected lengths, set for different temperatures can operate independently. Rugged, solid-state design provides constant, fast-acting protection . . . requires no resetting. *A positive, trouble-free system!*

The Fenwal Over-Heat Detector has proved itself everywhere in aircraft and missiles. It's equally applicable in industry: on bearings, in grain storage areas, in catalyst beds and other petrochemical processing units. *There's no end to its uses!*

Your processing operations would be *better protected* at many points with Fenwal Line Temperature Detectors. Talk over your application with a Fenwal Sales Engineer. Write Fenwal Incorporated, 368 Pleasant Street, Ashland, Mass.

Alarm connects directly to control unit of the Fenwal Continuous-Line Over-Heat Detector at point of protection; or by simple wiring at centralized panel. Sensing lengths available for temperatures from 255° to 1200°F.



ANOTHER EXAMPLE OF HOW **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

CIRCLE 10 ON READER-SERVICE CARD

detector in the klystron control loop, and a frequency standard and receiver for measuring the klystron shift. The receiver may contain a voltage-controlled oscillator serving to track the difference between the klystron output frequency and the frequency standard. In this case the control voltage could appear on a meter to show the cavity deviation from the nearest mil mark.

W. M. Kendrick
Aberdeen Proving Ground, Md.

Editor, I&CS:

Congratulations on your magazine's new name and purpose. In this day when literature on instruments seems to be drifting entirely to guided missiles and machine tool control, it is reassuring to know that your journal will be dedicated in part, at least, to the long-suffering field of process control. The cover of your February issue is a sight for sore eyes!

Greg Shinskey
Instrument Engineer
Olin Mathieson Chemical Corp.
Niagara Falls, New York

"Long suffering" is an appropriate description. We hope to relieve your discomfort.

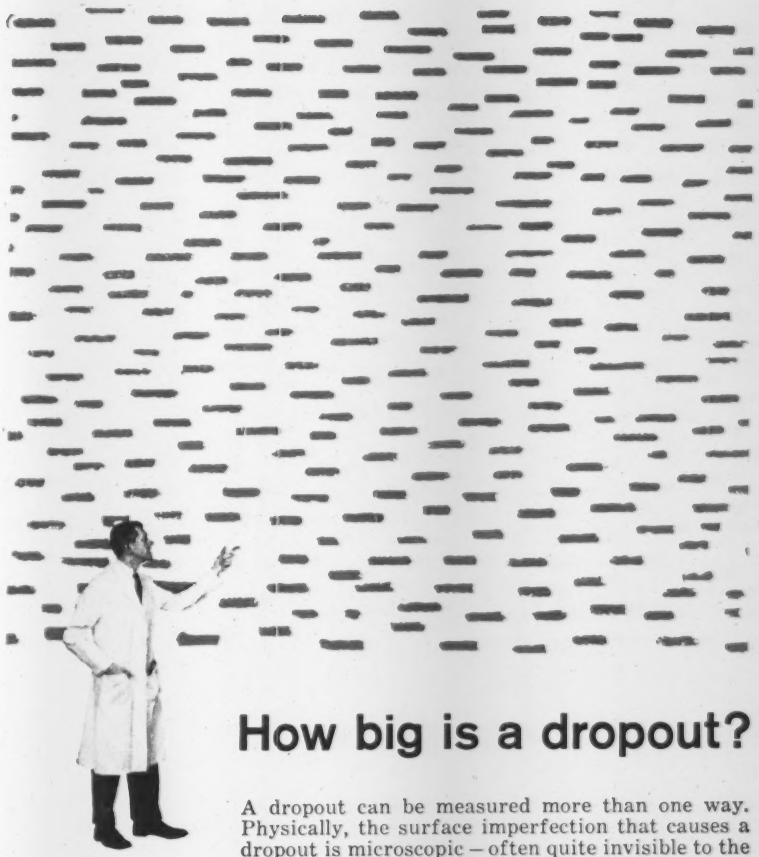
Editor, I&CS:

I am an instrument mechanic in the steel industry and have been a reader of your magazine—*INSTRUMENTS*—for the last ten years. I have never taken the trouble to tell you about your great magazine.

I have found your magazine very valuable. There are many articles that don't pertain to steel-mill instrumentation, and it sometimes seems like a long wait for such articles, but the waiting is justified because when they do appear, they contain the type of information I need.

It appears that the steel industry is starting to change its mind about higher education and leaders . . . they have found some of their own employees have higher IQ's than many college graduates. Youngstown Sheet & Tube has found that colleges do not train leaders. Leadership is not found in a text book but only through experience. It would be interesting to see a paper on the subject.

I have a problem. A fuel engineer and I have a disagreement on a metering problem. What is the best



How big is a dropout?

A dropout can be measured more than one way. Physically, the surface imperfection that causes a dropout is microscopic – often quite invisible to the naked eye. Financially, though, this molehill can become a mountain – may cost you thousands of dollars from a single error.

That's why our customers invariably demand perfection from our EP Audiotape, the extra precision magnetic recording tape. They just can't afford dropouts.

Audio Devices' battery of Automatic Certifiers is one of the unique means used to make sure EP Audiotape always meets customer specifications. The Automatic Certifier records and plays back every inch of the EP Audiotape under test. These tests can be so demanding that if the tape fails to reproduce just one test pulse out of the 40 million put on a single reel, the entire reel is rejected. There are no ifs, ands, or buts.

This is one of many special quality-control operations to which EP Audiotape is subjected. From raw material to hermetically sealed containers, every reel gets individual attention.

EP Audiotape quality is so well verified by instruments like the Automatic Certifier that every reel is guaranteed to be defect-free! For more information write for free Bulletin T112A. Write Dept. I-I, Audio Devices, Inc., 444 Madison Avenue, New York 22, N. Y.

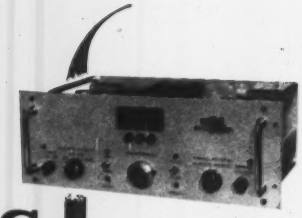
TYPE **EP audiotape** TRADE MARK

AUDIO DEVICES, INC.
444 Madison Ave., N. Y. 22, N. Y.
In Hollywood: 840 N. Fairfax Ave.
In Chicago: 5428 Milwaukee Ave.
Export Dept.: 13 East 40th St., N. Y., 16
Rectifier Division: 620 E. Dyer Rd., Santa Ana, Calif.

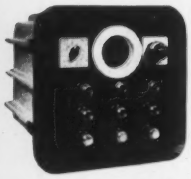
CIRCLE 11 ON READER-SERVICE CARD

COX *Electronic*

FLOW MEASURING SYSTEM

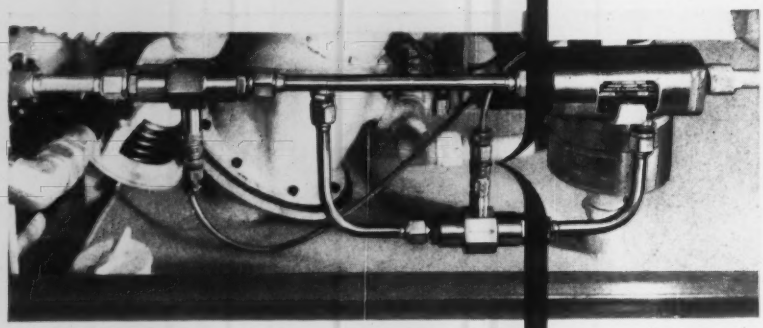


RACK MOUNTED INDICATOR



EXPLOSION-PROOF INDICATOR

COX Instruments brings you the most advanced development in flow measuring equipment: *A calibrated, integrated flow measuring system with a guaranteed system accuracy of ± ½% and flow ranges of 1:1000.*



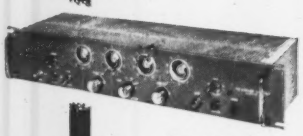
Developed for the missile age, the COX *Flow Measuring System* consists entirely of COX-built components. It comprises a turbine flow transducer; a choice of continuous reading digital indicators, counter, or dial indicator; and a manifold assembly with a unique automatic by-pass valve. All are calibrated for *system accuracy* of ½%.

TRANSISTORIZED INDICATOR

COX *Flow Measuring Systems* are in use in many aircraft and missile industry laboratories. We welcome the opportunity to tell you more about them.

DIAL INDICATOR

Write for our new bulletin No. 2027. *Cox Instruments Division, George L. Nankervis Company, 15400 Fullerton Avenue, Detroit 27, Michigan.*



COUNTER

Precision Instruments Since 1912 7391

COX Instruments

CIRCLE 12 ON READER-SERVICE CARD

LETTERS—CONTINUED

meter technique for measuring tar, or #6 fuel oil (Bunker C)? How would viscosity affect the accuracy of each type? Why do some companies (user) have trouble with a meter while others using the same meter do not?

Richard C. Norman
East Gary, Indiana

Leadership usually appears only after years of experience on a job, and is fairly independent of education. This makes it difficult to trace the sources of leadership. Most of what has appeared in print on this subject is shallow, ambiguous and useless—exactly the type of material we try to keep out of *INSTRUMENTS*—for your benefit.

The major firms who meter tars and #6 fuel oil use two techniques, either area-type meters or orifice-type. Frankly, you have raised one of the "sticky" problems of the flow-metering field. Both techniques leave something to be desired in accuracy for viscous fluids, and both are affected by the viscosity of the fluid. This viscosity effect is minimized by use of a very high differential in the Hagan orifice and Bailey area meter technique. We will have more for you on this subject soon.

The reason why some meter installations operate properly while others do not is the ability of the instrument mechanic who installs and calibrates the instrument; a secondary reason is to be found in the small variations between presumably identical items. Two similar meters, like two similar Fords, have individual characteristics. This is where the instrument engineer steps in—he makes possible accurate and reliable measurement and control with any operable instrument.

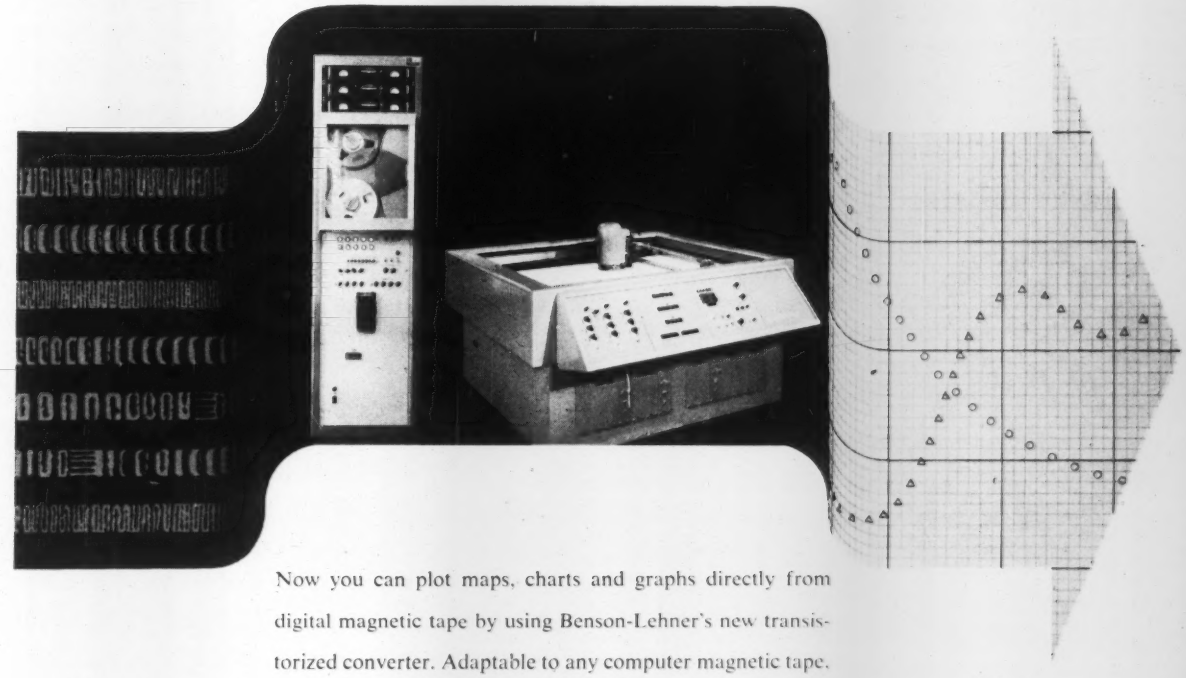
Editor, I&CS:

Thanks for the manner in which you presented Dr. Kintner's "Mapping System Uses Digital Printer", in the June issue of *Instruments & Control Systems.*

Your presentation is fantastic. How you took 15 pages of typed material and reduced them to 2 pages of intelligent readable text is a brilliant example of the way an engineer-editor works.

Harold Hechtman
Airborne Instruments Laboratory
Mineola, New York

new! from
benson-lehner...
direct display
from
magnetic tape!



Now you can plot maps, charts and graphs directly from digital magnetic tape by using Benson-Lehner's new transistorized converter. Adaptable to any computer magnetic tape, it eliminates the need for conversion to punched cards and will more than double the speed of the Benson-Lehner ELECTROPLOTTER you already own! By converting digital tape data to an analog voltage, it provides a compatible input for many automatic graph plotters and X-Y recorders. Write now for information or to have an applications engineer help establish your exact requirements.

B L benson-lehner *Corporation*

1860 Franklin Street • Santa Monica, California
OFFICES: LOS ANGELES; WASHINGTON, D.C.; DAYTON, OHIO
Service Center in 28 cities throughout the world.

CIRCLE 13 ON READER-SERVICE CARD

In Masoneilan Transmitters . . .

Masoneilan Transmitter with cover removed showing compact, simple design.

CIRCLE 14 ON READER-SERVICE CARD

Important Design Features Give You Top Performance

Accurate, dependable pneumatic transmission of pressure or temperature is assured by these compact, lightweight, force-balance transmitters. In addition to the advantages inherent in this class of instruments, the Masoneilan design offers a number of features which make them outstanding.

1. **Balanced beam permits mounting in any position without zero shift; permits changing position at will without rezeroing.**
2. **High accuracy — for example a 100F span temperature transmitter set for 0-100F is accurate within ±0.5°.**
3. **Locked span-location setting is unaffected by vibration — will not shift.**
4. **High capacity, balanced relay speeds transmission; permits longer transmission lines.**
5. **Derivative unit and integral receiver gauge may be added without tubing and without removing cover.**
6. **Unit subassembly construction permits changeover from temperature to pressure (or vice versa), or change of span, without disturbing beam.**

Simplicity and unit construction, plus compact ruggedness, make these transmitters very easy to install and maintain. This, plus moderate first cost, makes them a topnotch investment in improved measurement and control. Send for your copy of bulletin.

MASON-NEILAN

A Division of Worthington Corporation

55 NAHATAN STREET, NORWOOD, MASSACHUSETTS

District offices or Distributors in principal cities in U.S.

In Canada: Mason-Neilan, Division of Worthington (Canada), Ltd.

MN9-9

CIRCLE 14 ON READER-SERVICE CARD

Choose From The Widest Variety Of Thermocouple Wires

Over 1500 Different Types

T-E's tremendous variety of thermocouple extension wires assures you quick delivery of every type and size—from one reliable source. Dependable quality control is also assured by T-E's own complete facilities for wire drawing, insulating and calibrating. T-E duplex wires come in solid or stranded construction, in all standard calibrations. The latest types of insulation and metallic armor overbraid protect them from all atmospheric, chemical and abrasive conditions. From 6 to 56 pairs of T-E thermocouple leads can now be installed at one time with the new "Thermo-Cable". Also available—a complete selection of "MIL"- Spec Wire.

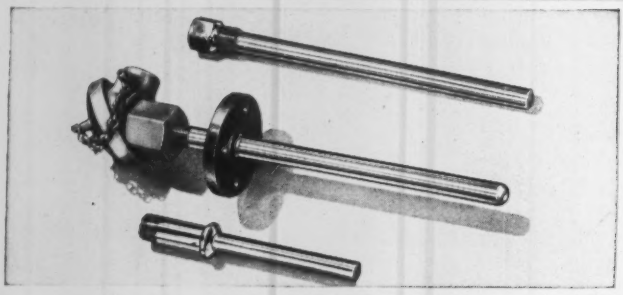
See Our Full Line—

Write for Wire Bulletin 32WS-F

Thermo Electric CO., INC.
SADDLE BROOK, NEW JERSEY

In Canada:
THERMO ELECTRIC (Canada) LTD.,
Brampton, Ont.

SEE THERMO ELECTRIC'S BOOTH 525—I.S.A. SHOW
CIRCLE 15 ON READER-SERVICE CARD



Complete Range Of

Thermocouple Assemblies

With T-E's thermocouple assemblies you get: (1) choice of an extremely wide variety; (2) carefully pre-tested quality; (3) simplified ordering – one code number for a complete thermocouple assembly.

Thermocouples – Wire type from 20 to 6 gage. Ruggedly constructed, sensitive in performance. Available with fiberglass or various types of ceramic bead insulation. Calibrated in Iron-Constantan, Copper-Constantan or Chromel-Alumel.

Connection Heads – Choice of various connection heads – heavy duty, lightweight, weatherproof, etc. Available with nipples and unions in a variety of sizes and lengths.

Thermowells – Bar stock or built-up, straight or tapered, with threaded, flanged or ground-joint mountings. Available in all commercial materials for all applications.

Write For Thermocouple Catalog Section E-F

Thermo Electric Co., Inc.
SADDLE BROOK, NEW JERSEY
In Canada—THERMO ELECTRIC (Canada) Ltd., Brampton, Ont.

CIRCLE 16 ON READER-SERVICE CARD

reader inquiries

Ophthalmograph

Advertising agency seeks maker of device "which records the eye movement in relation either to the advertising or display material (ophthalmograph)." A-417

Testing of Distribution Transformers

Electric company seeks contractor who can perform impulse testing of prototype distribution transformers according to ASA code C57.22 or NEMA code TR3-60. "Equipment required would be a surge generator capable of producing the standard 1½ x 40 μsec pulse to test at 88 kv crest for a chopped wave and 75 kv crest for a full wave." A-418

Ultrasonic Soldering, Electrostatic Pistol

Engineer is interested in purchasing a small ultrasonic soldering set; also an electrostatic pistol. A-419

Mass Flowmeter

Attorney seeks consulting assistance on the subject of mass flowmeters. A-420

Trade Schools

Educational committee of Engineering Society seeks lists of Trade Schools teaching Industrial Instrumentation; Basic Electronics as applied to Transmission; Telemetering and Measuring Circuits for Industrial Instrumentation; and Refrigeration and Air Conditioning. A-421

Displacement Transducer

General manager of anesthesia-and-oxygen-appliances manufacturing company seeks "instrument which will read on a circular dial the speed of a reciprocating shaft in pulses per minute." A-422

Fly Ash Measurement

Plant engineer in atomic product installation seeks equipment to measure foreign material ejected from boiler stacks. A-423

Company Identification

Manager of electronic supply house seeks maker of "Youell milliammeter, 3½" square, panel mounted, self-fused or self-protected, dc, range 0-3 ma." A-424

Pyrometer

Electronic specialist of large tobacco concern seeks "an IR temperature measuring device which gives a direct reading of the temperature at a point a given distance away." A-425

Magnetic Oscillograph

Research engineer for paper machine manufacturer seeks inexpensive magnetic oscillograph and electronic amplifier for it. A-426

Design does make a difference

in the NEW Thermo® Electronic

Signaling Controller
Self Balancing Indicator
Indicating Recorder

Modern design—proven components—these are the hallmark of the new Thermo Electronic Instruments. And the proof of the pudding, in this case, is in the applicability.

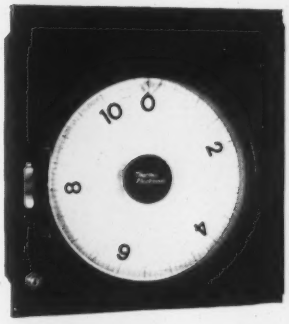
No matter what your process measuring requirements, these instruments will prove unsurpassed for versatility, dependability, long-lived accuracy, sensitivity and speed of response. They will measure any variable translated to DC potential, current or resistance. The instruments have been specially designed for front-set adjustment, ease of operation and maintenance, quick, in-the-field, interchangeability of components and ranges, (from 1 to 100 millivolts). Accuracy is ±0.25% of full scale—sensitivity is ±0.125%. The exclusive new high-gain amplifier, which couples extreme sensitivity with exceptional stability, is utilized in each instrument.

Size

Signaling Controller
Off-on, Potentiometer or Bridge Type

Takes just 56 square inches of panel space. Rugged, compact Signaling Controller automatically, continuously controls any process through DC signaling transducers. Corrective action is almost simultaneous with even a 1 microvolt signal change. Bright red-green lights show process condition. Provides built-in fail-safe action—fully automatic reference junction compensation.

See these and many other Thermo Electric Instruments at the I.S.A. Show—Booth No. 525



Readability

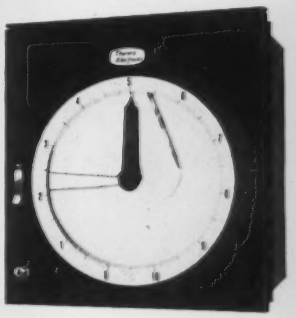
Self Balancing Indicator
Potentiometer or Bridge Type

Rapidly, automatically indicates condition at any one of several hundred sensing elements connected through multi-point switches. Large 34″ scale is easily seen from a distance. Built-in fail-safe action—optional 2 or 3 position controls—up to 6 alarm contacts available.

Versatility

Indicating Recorder
Potentiometer or Bridge Type

Versatility personified, the Indicating Recorder will automatically indicate and record any variable converted to a DC voltage or resistance change. Fine-line recording pen rarely needs refilling. Large 34″ dial is clearly visible from a distance. Full scale pointer and pen travel takes just 5 seconds. Provides built-in fail-safe action—optional 2 or 3 position controls, and up to 6 alarm contacts.



Write today for Bulletin 156-F

Thermo Electric CO., INC. SADDLE BROOK, NEW JERSEY
In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ontario

CIRCLE 17 ON READER-SERVICE CARD

SEE PROOF* OF BARTON FLOW METER PERFORMANCE

1. **INSTANTANEOUS TEMPERATURE COMPENSATION!**
2. **POSITIVE OVERRANGE PROTECTION WITH NO ZERO OR CALIBRATION SHIFT!**

Visit our Booth No. 610 at the I. S. A. Show, International Amphitheater, Chicago, September 21st thru 25th, 1959.

*See PROOF of Barton's instantaneous temperature compensation and immunity to the effects of excessive overrange.

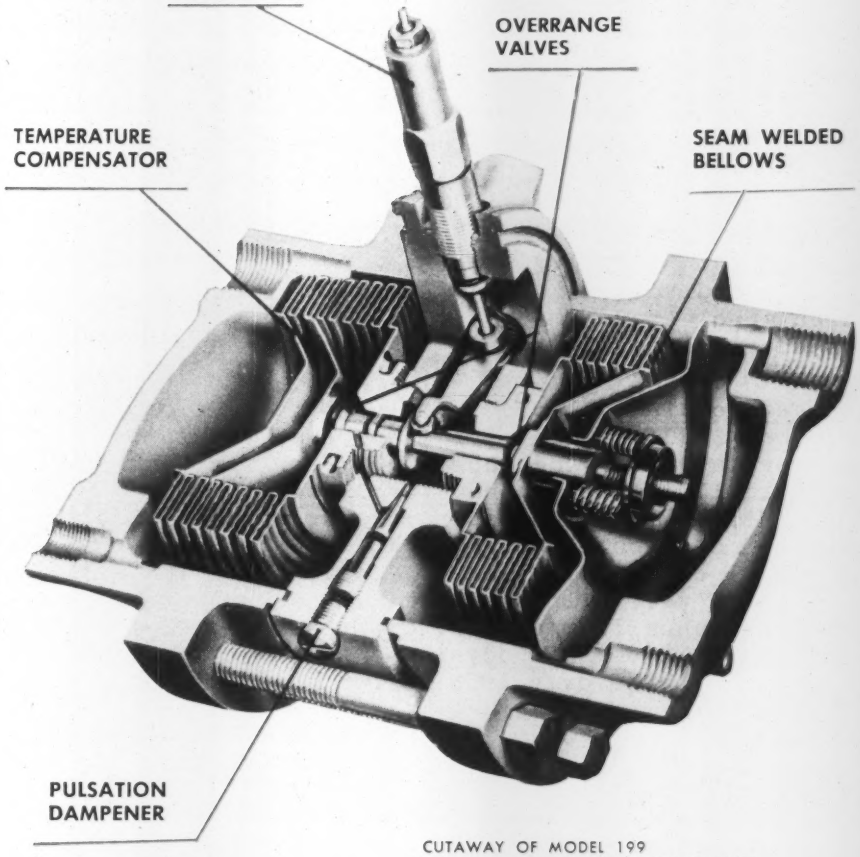
The MODERN BARTON instrument is backed by fifteen years of design and manufacturing "know-how" with over 100,000 rupture-proof units delivered.

Representatives in most principal cities in the U.S.A. and all over the world.

CIRCLE 18 ON READER-SERVICE CARD

ONLY **BARTON**, THE ORIGINAL RUPTURE-PROOF BELLOWS METER, CAN OFFER **ALL** THESE PATENTED FEATURES!

MODEL 202
DIFFERENTIAL PRESSURE RECORDER

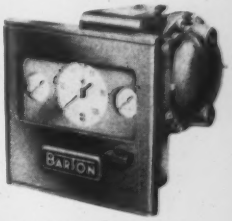


CUTAWAY OF MODEL 199
DIFFERENTIAL PRESSURE UNIT

MODEL 200 INDICATOR

MODEL 211 FLOW SWITCH

MODEL 214 TRANSMITTER



MODEL 237 CONTROLLER

MODEL 243 INTEGRATOR

Available with differential pressure ranges from 0-20WC to 0-50 psi with SWP to 6000 PSIG. Every Barton unit is hydrostatically overranged in both directions to 1.5 times the safe working pressure, regardless of the differential range.

BARTON INSTRUMENT CORPORATION

580 MONTEREY PASS ROAD MONTEREY PARK, CALIFORNIA

CIRCLE 18 ON READER-SERVICE CARD

Research payoff comes from only 10% of projects undertaken, and time lag between initiation of project and new marketable product is 10 years, says D. G. Mitchell of Sylvania—but this payoff is as much as 100 to 200% per year. That is, for every $100 spent on research, return over 25-year period has been from $2500 to $5000.

Basic research spending in USA is $670 million annually, says A. T. Waterman, NSF—48% government, 33% industry, 19% universities and non-profit organizations.

More than 65 Russian technical trade publications are now available in English translation, at prices from $10 to $215 annual subscription.

First fully mechanized post office, said to be world's first, is scheduled for completion Sept., 1960, Providence, R. I. Every mail processing step will be controlled by an IT&T computer.

OEEC predicts that by early 1960's Europe will have installed nuclear capacity of 10,000 megawatts; USSR will have 2000 megawatts; USA will have 1300 megawatts; Japan 750; India 500; By 1975 most new power stations will be nuclear.

After-work market (recreation, culture, self-development) is now $18 billion/year market. Recreational travel market is additional $12 billion/year. Economic aspects are being studied by Stanford Research Institute.

Electronics components market for 1959 is previewed by L. B. Davis of GE as follows: Receiving tubes $380 million (10% above 1958 total of $345), divided between commercial receiving tubes ($300 million) and industrial and military ($80 million). Semiconductor dollar volume (rectifiers, diodes and transistors) in 1959 is expected to reach $255 million (30% above 1958's $195 million). Rectifier sales are expected to increase 50% from 1958 level of $33 million to $50 million; transistors from $104 million to $140 million; 62 million transistors will be sold at prices 7% lower than 1958 prices. Diode sales will increase from $58 million to $65 million. Cathode-ray-tube market, (including TV picture tube) will be up 5% over 1958 to reach $265 million (12.3 million units).

1959 electronics market is predicted by Electronics magazine as follows: Total Revenue $14.4 billion (1958 was $13.2 billion); military electronics $5.3 billion ($4.5 in 1958); industrial-commercial $1.57 billion ($1.38 in 1958). Latter category includes $235 million for test instruments ($220 million in 1958) and $170 million for industrial control ($160 million in 1958), $310 million data processing ($258 million in 1958), $50 million atomic instrumentation ($42 million in 1958), $8 million ITV ($7 million in 1958).

Survey of electronic engineers by Electronic Industries shows that average electronics engineer is (1) under 40 years old; (2) has degree in EE (44%); (3) earns $10,000/yr; (4) uses trade magazines as prime source for information; (5) served in armed forces, and (6) owns car and home.

NEW NEW NEW NEW

TYPE T

The economy cable, Type T Dekoron Multicouple Cable consists of insulated, numbered and twisted wires covered with 90% closed No. 30 cotton braid and outer sheath of .050" thick 105°C PVC. Moisture and chemically resistant; approved for direct burial. Can be installed without conduit, or with smaller conduit when necessary.

TYPE A

Same construction as Type T, above, except has outer covering of modified square lock galvanized steel armor overall which shields cable, serves as conduit and provides crush resistance with great flexibility.

TYPE AT

Type AT Dekoron Multicouple Cables incorporate all advantages of Types A and T. Consists of armored Type A sheathed with .050" thick 105°C PVC. Moisture, chemical, and high crush resistance. Approved for direct burial or installation without conduit in open racks.

DEKORON

MULTICOUPLE EXTENSION WIRE

Dekoron multiple pair harness of thermocouple extension wire is available *now* in three constructions, each in either Iron-Constantan or Chrome-Alumel. All are guaranteed to *meet or exceed ISA specs* for standard grade extension wire.

And — equally important — all are designed to drastically reduce thermocouple extension wire costs. Dekoron Multicouple Extension Wire reduces installation and maintenance time . . . often cuts initial material costs . . . *always lowers installed costs.*

A-114A

Dekoron® products QUALITY • RESEARCH • SERVICE

SAMUEL MOORE & COMPANY

DEKORON PRODUCTS DIVISION • MANTUA, OHIO

CIRCLE 19 ON READER-SERVICE CARD

news

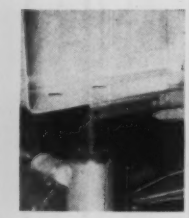
Chicago to Host ISA Show

CHICAGO, ILL.—The ISA will hold its Fourteenth Annual Instrument-Automation Conference and Exhibit September 21 through 25 in Chicago. The International Amphitheater will house the Show, while the Conference will be held downtown in two loop hotels, the Palmer House and the Morrison Hotel. About 100 papers will be presented, of which preprints will be available for $8.00 to registering members ($12.00 to non-members), and for $12.00 and $18.00, respectively, for non-registrants. Clinics are scheduled on Steel and Ceramics; Chemicals and Petroleum; Power Plants; Food; and General Instrumentation. Seven Workshops are planned. A ladies' program, banquet, and plant tours round out the activities.

Fred Lennon, president of Crawford Fittings Co., as in previous years, will provide free bus service for Exhibit visitors between the Loop hotels and the Amphitheater.

Blind Riveting

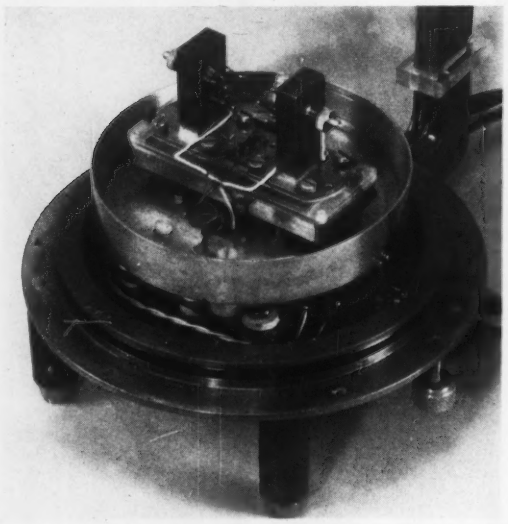
At one point during the design stages of a new series of temperature and pressure control instruments (Fig. 1) the Powers Regulator Company, Skokie, Illinois, ran into a problem that is not uncommon—how to rivet mounting brackets to a housing without expensive tooling. The blind-riveting scheme they adopted is the essence of simplicity, requiring a vise, a foot-treadle, rivets, and a portable hand gun used to set them.



The rivet selected was the "POP" Rivet. Made by the Pop Rivet Division of United Shoe Machinery Corp., this rivet fundamentally is a blind fastener, but can be used in practically any hard-to-get-at-area. Consisting of a hollow, heavy-walled shank through which a mandrel extends, it is set from one side by pulling the mandrel into the shank to spread and set it. At a predetermined point, the mandrel breaks. Two types of tools can be used to pull the mandrel—hand pliers or a lightweight hydraulic hand gun that operates off a conventional compressed-air system. The rivet gun is held in a vise and operated from a foot-treadle giving the operator freedom to use both hands in holding and positioning parts (Fig. 2). This is especially important in riveting two small parts together for the sensitivity bar adjustment assembly (Fig. 3).

International Comparisons of Microwave Power Standards

WASHINGTON, D. C.—URSI, the International Scientific Radio Union, more than ten years ago recommended international inter-comparisons of power standards in the microwave region. Hitherto discrepancies between the American, the British, and the Japanese standards could not be resolved.



Recently an NBS standard bolometer mount which had been calibrated by the Bureau's microcalorimeter was compared with the British standard at the Radio Research Station in England, and showed an "effective efficiency" of 97.2% at a frequency of 9375 MC/S, which is within 1.3% of the value of 98.5% determined by the Boulder Labs of NBS.

A comparison with the Japanese standard in 1957 showed a discrepancy several times larger than estimated and was at that time attributed to the comparatively long time which had elapsed between the measurements in the two countries.

Picture shows interior of the refined microwave microcalorimeter.

Russell H. Varian

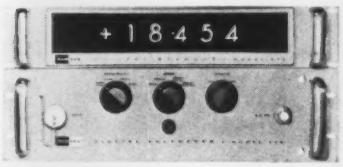
Russell H. Varian, chairman of the board of Varian Associates, died of a heart attack July 28, while on a vacation cruise in Alaska with his family. He was 61 years old.

A graduate of Stanford University (he received his master's degree in 1927), he was instrumental in the development of the Klystron which led to effective radar. Polytechnic Institute of Brooklyn recognized his work by presenting him with an honorary doctor's degree. Mr. Varian also was awarded the John Price Wetherill Medal for remarkable research.

He is survived by his wife Dorothy, two sons and a daughter.

This unique "extra" fifth digit...

...provides 100% over-ranging...ten times greater resolution at decade voltage points where other 4-digit voltmeters change ranges and lose one full digit of resolution.



The KIN TEL Model 501 4-digit, over-ranging digital voltmeter measures DC from ±0.0001 to ±1000.0 volts with 0.01% ±1 digit (of reading) accuracy. An extra fifth digit in the left decade indicates "0" or "1" to provide ten times greater resolution at decade (1, 10, 100) voltage points than standard 4-digit voltmeters. Ranging and polarity indication are entirely automatic. The measured voltage, decimal point and polarity symbol are displayed on an in-line readout in a single plane–no superimposed outlines of "off" digits.

An adjustable sensitivity control permits decreasing sensitivity to allow measurement of noisy signals. Ten-line, parallel input printers can be driven directly, and converters are available for driving other types of printers, typewriters, and card or tape punches. The input may be floated up to 25 volts DC above or below chassis ground with no degradation in performance, and up to 250 volts DC with slight decrease in accuracy. Stepping-switch drive coils are energized with DC as in telephone-type service to provide long, trouble-free operation.

The 501 is one of a complete line of KIN TEL digital instruments. Others include AC converters, AC and DC preamplifiers, ratiometers, and multi-channel input scanners.

IMPORTANT SPECIFICATIONS

Display...Six decades display 5 digits (Left digit "0" or "1" only), decimal point, polarity symbol. Ranging and polarity indication are automatic. Projection system readout employs bayonet-base lamps with 3000-hour minimum life rating. Readout contains no electronic circuitry and can be remotely mounted.

Automatic Ranges...±0.0001 to ±1000.0 volts DC in four ranges: 0.0001 to 1.9999; 02.000 to 19.999; 020.00 to 199.99; 0200.0 to 1000.0

Accuracy...0.01% ±1 digit (of reading).

Input Impedance...10 megohms on all ranges at null.

Reference Voltage...Chopper-stabilized supply, continuously and automatically referenced to standard cell.

Stepping-Switch Drive...DC voltage within stepping-switch manufacturers rating applied by transistor drive circuit at rate of approximately 20 steps per second.

Controls...Three: on-off; sensitivity; and mode of operation (standby, normal, print auto, print remote).

Printer Drive...Built-in for parallel input printers. Automatic or remote.

Dimensions and Net Weights...Control unit: 45 lbs, 5¼"H x 19"W x 16"D. Readout: 10 lbs, 3½"H x 19"W x 9"D.

Price: $2995

KIN TEL manufactures electronic instruments for measurement and control, and closed circuit TV. Representatives in all major cities. Write for detailed literature or demonstration.

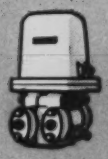
KIN TEL
A DIVISION OF
COHU
ELECTRONICS, INC.

5725 Kearny Villa Road, San Diego 11, California, Phone: BRowning 7-6700

CIRCLE 20 ON READER-SERVICE CARD

Indicating Motion-Type Transmitters

... for flow, pressure, and level

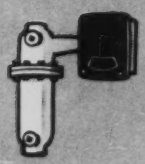


Low Displacement Force-Balance Transmitters

...for flow, pressure, and level

Thermocouple and Resistance Bulb Converters

... magnetic amplifiers... no vibrators
... no mechanical rebalancing

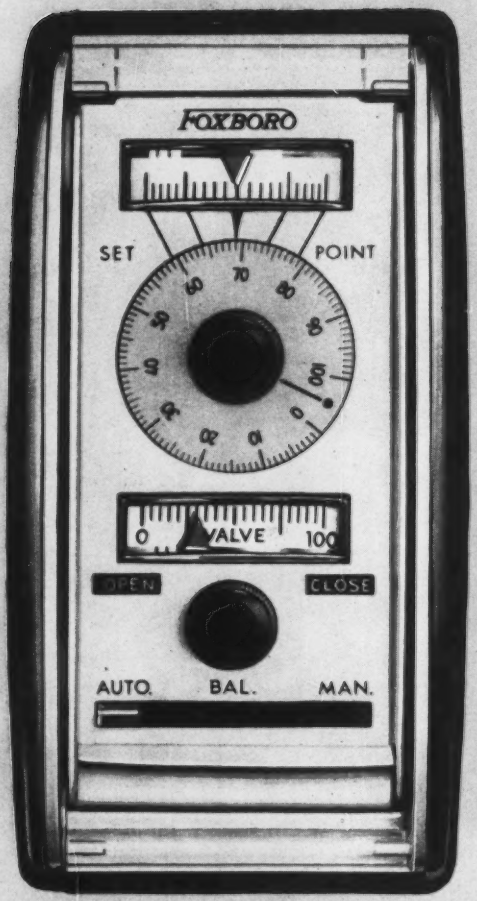


Displacer Level Transmitters

...force-balance for simplicity

Control Valves

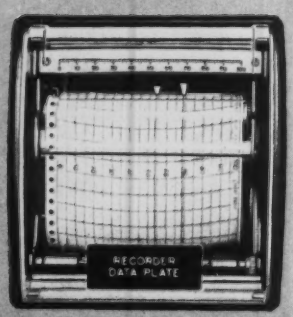
...electro-pneumatic and electro-hydraulic actuators



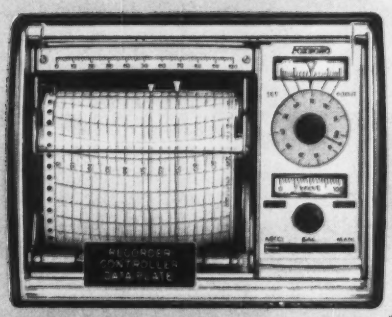
CONTROLLER
The Electronic Consotrol Controller (shown 4/5 actual size) concentrates all control and supervisory functions in one slim 3 x 6 inch case. Controller operation is entirely independent of recorder.

FOXBORO Electronic

REG. U.S. PAT. OFF.



RECORDER
Electronic Consotrol Recorders (shown ¼ actual size) use a simple, powerful pen motor which can be operated directly from transmitter signal without amplification. Available in 1 and 2 pen models.



COMBINED RECORDER-CONTROLLER
Electronic Consotrol housing design permits unequalled flexibility in panel arrangement. Recorders and controllers can be mounted separately in individual housings—or enclosed in a compound unit. Regardless of mounting, either unit pulls out independently.

for the first time... the 100% solid state electronic system!

- thermocouple and resistance bulb converters-using magnetic amplifiers
- choice of force-balance and motion-type transmitters
- long time-constant tubeless controllers

Consotrol Instrumentation

Electronic Consotrol* Instrumentation—the most complete and advanced family of electronic-operated measurement and control instruments available today! That just begins to describe Foxboro's dramatic new advance in instrumentation. ✓ ✓ ✓ Foxboro electronic transmitters, indicators, recorders, control stations, computing stations, valve actuators and other final operators cover every function in the control loop. All are linked by a d-c current signal. All are completely tubeless. Even thermocouple and resistance-type systems no longer require vacuum tubes. ✓ ✓ ✓ Electronic Consotrol systems convert temperature, pressure, flow, level, and other measurements, to a proportional signal **at the transmitter.** Transmission to a remote control station is instantaneous. Designs are available for both hazardous and non-hazardous areas. ✓ ✓ ✓ Electronic Consotrol Instrumentation heralds a whole new era in process control engineering. Write Foxboro today for the new 32-page Catalog 21-10 which gives full details. **The Foxboro Company, 468 Neponset Ave., Foxboro, Mass., U.S.A.**

*Reg. U.S. Pat. Off.

CIRCLE 21 ON READER-SERVICE CARD

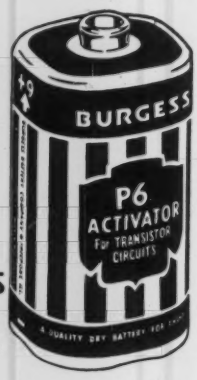
What do you need in Battery Power?

ZINC-CARBON? MERCURY?
NICKEL-CADMIUM?
WATER-ACTIVATED?

MORE THAN 5,000 BURGESS BATTERY TYPES

each with the highest measure of uniform dependability! This is why 2 of 3 electronic engineers specify

BURGESS BATTERIES



BURGESS

IS THE MOST COMPLETE ONE-SOURCE LINE OF *Portable Power!*

EXCLUSIVE WAFER CELL CONSTRUCTION

. . . offers compactness, long shelf life, exceptional service life. A 30% increase in battery life at no increase in size.

TRANSISTOR ACTIVATORS

Burgess Activator Batteries for transistor circuits are smaller and more compact in size! Yet they deliver 30% more power because of the patented "Wafer-Cell" construction! Burgess Activators give you compact power, uniform performance, longer shelf life . . . all combined with modern packaging.

RESERVE BATTERIES

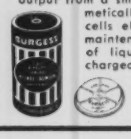
High energy output in a compact power source. Can be stored dry for years! Activated only when immersed in water. No handling of dangerous electrolyte, no spilling or leaking! Wide range of efficient operating temperatures. Designed for your specific applications.

MERCURY ACTIVATORS

Burgess constructional features provide *uniform quality* and *dependable service!* Burgess *exclusive* patents offer sealed-in-steel protection, wide temperature range efficiency, controlled venting, patented inner cell connector, and flat discharge curve.

SEALED NICKEL-CADMIUM BATTERIES

A secondary rechargeable battery system which delivers high energy output from a small package! Hermetically sealed-in-steel cells eliminate annoying maintenance and addition of liquids. Can be recharged many times, by trickle or quick charge, for long lasting economical power!



Check with your Burgess Distributor for complete local stocks of fresh BURGESS BATTERIES! Or your distributor can order from Burgess the special battery needed for your specific application!

FREE DESIGN SERVICE

For special applications, skilled Burgess Engineers offer you a FREE battery design service. Burgess will manufacture the exact battery to fit your needs, regardless of quantity required.

NEW ENGINEERING MANUAL

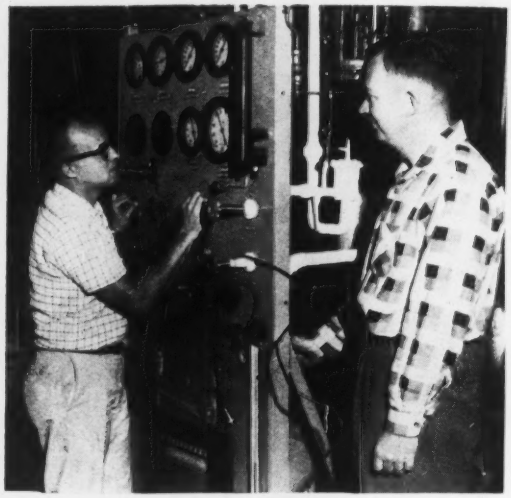
New 100-page dry battery handbook now available! Engineers engaged in the design of battery-powered equipment are invited to write to Burgess Battery Company, Dept ICS, Freeport, Ill., to secure a copy. Others may buy the manual for $1.00.

BURGESS BATTERY COMPANY
FREEPORT, ILLINOIS

CIRCLE 22 ON READER-SERVICE CARD

Liquid Refrigerants for Research

WASHINGTON, D. C.—NBS, engaged in a program of free radicals research, uses considerable quantities of liquefied gases, including helium, nitrogen, and hydrogen. Lack of immediate access to liquefaction facilities has sometimes hampered the scientists.



A solution to this problem has been found by buying the liquid gases from commercial sources and transporting them over long distances with little loss.

Helium, liquefied in considerable quantities at the NBS Boulder (Colo.) Laboratories, is now flown regularly the 1700-mile distance to Washington. Liquid hydrogen is purchased from a commercial source 500 miles away and safely transported by truck. Liquid nitrogen is purchased locally.

Picture shows liquefaction facilities of the Bureau's Cryogenic Engineering Lab in Boulder with Manning, Maxwell & Moore pressure gages and a Minneapolis-Honeywell strip chart recorder conspicuous on the panel board.

AIR MATERIAL COMMAND (AMC) officials say that by the end of the year almost half of the Air Force bases will be equipped with precision calibration laboratories.

IBM'S RAMAC 305 will be used in the candy industry; NECCO will use one for simultaneous billing and inventory control.

CORNELL UNIVERSITY is currently holding a two-month international training course on atomic energy in agricultural research.

GENERAL ELECTRIC's Atomic Power Equipment Dept. (APED), at Vallecitos Atomic Lab, announces completion of an eight-day experiment in which electricity was directly produced from a radioisotope using a thermionic converter under gamma radiation conditions. Gold was used as the radioactive source material.

In another nuclear development GE scientists have succeeded in "finger-printing" atoms by mass spectrometer, to determine the atomic weight of isotopes.

THOMAS A.

EDISON

omniguard systems protect equipment, decrease downtime in generating plants

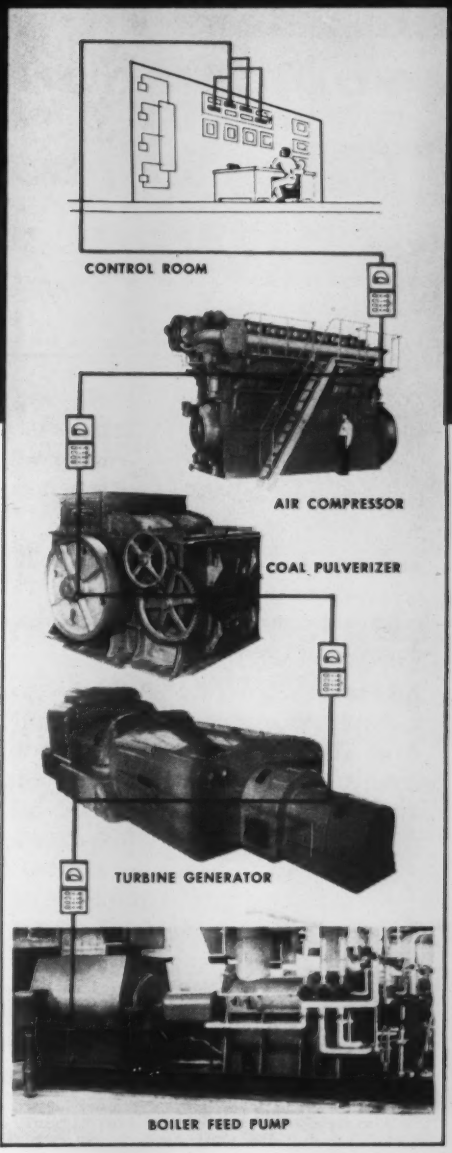
The Edison Omniguard system keeps constant watch on critical temperatures throughout electric generating plants. Omniguard monitors such vital temperatures as those of bearings on the main turbine generator, fluid drives, coal pulverizers, main feed pumps and other vital auxiliaries.

When overheating occurs the alarm sounds *before* damage occurs and corrective action may be taken immediately.

By guarding against overheating the equipment runs at optimum efficiency, lasts longer and requires less maintenance.

This modern Edison system is a simple, reliable means of keeping equipment operating at full efficiency and protecting against emergency shutdown.

For additional information on Edison Model 310 Omniguard temperature monitor and the wide variety of detectors available for use on all types of auxiliaries, pressure vessels, tanks and pipe lines, write for publication 3036C.



See the newest missile control systems and components at Booth 2423 WESCON Show.

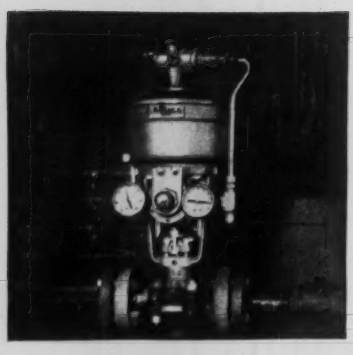
Thomas A. Edison Industries

INSTRUMENT DIVISION

24 LAKESIDE AVENUE, WEST ORANGE, N. J.

EDISON ENGINEERING OFFICES ARE LOCATED IN: CHICAGO; DALLAS; DAYTON; LOS ANGELES

CIRCLE 23 ON READER-SERVICE CARD



"Best valves we ever found for tight shutoff on our maleic acid lines" says Instrument Foreman of a well-known mid-west chemical plant.

YOU CAN COUNT ON

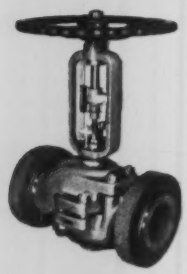
CONOFLOW LB CONTROL VALVES

FOR TIGHT SHUTOFF

Major chemical companies have switched to Conoflow Series LB Control Valves because they provide absolute tight shutoff, regardless of operating variables. Tight shutoff prevents waste of costly liquids and gases . . . insures precise process control.

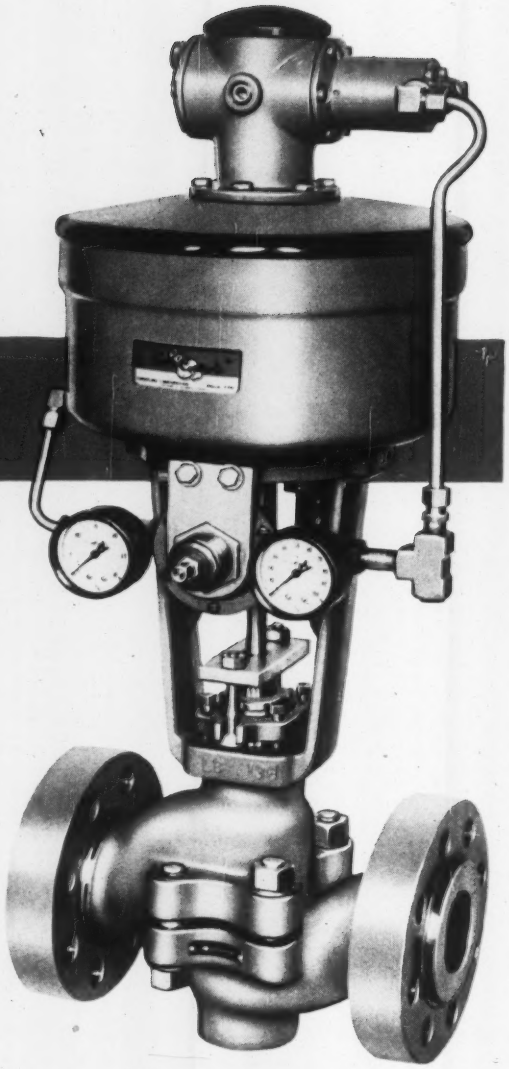
The answer is the single-seated body and the powerful cylinder actuator of the LB Valve. This integrated body-actuator design allows for leak-proof shutoff not possible with double-seated valves.

An added feature of the LB Valve is much lower all-around maintenance costs. Body separates easily at seat ring for tear down and inspection. Fewer replacement parts mean substantial inventory savings. Streamlined body contours and extra thick walls assure longer life in corrosive and erosive services. Also, when it comes to special alloys . . . type 316 Stainless steel, Hastelloys, Monel, Nickel, Everdur, etc., the single-seated LB Valve offers a substantial initial cost advantage over double-seated construction. By all standards, your overall cost is much less for a Conoflow Series LB Valve.

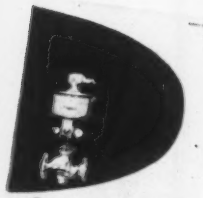


Also available with sturdy handwheel actuators for precise manual control.

If you are not already a user, try a Conoflow LB Control Valve . . . and let it prove itself.



Phone your nearest Conoflow representative (located in principal cities), or write to Conoflow Corporation, 2100 Arch Street, Philadelphia 3, Pa. for Bulletin LB-3-1A



Cono-Controls®

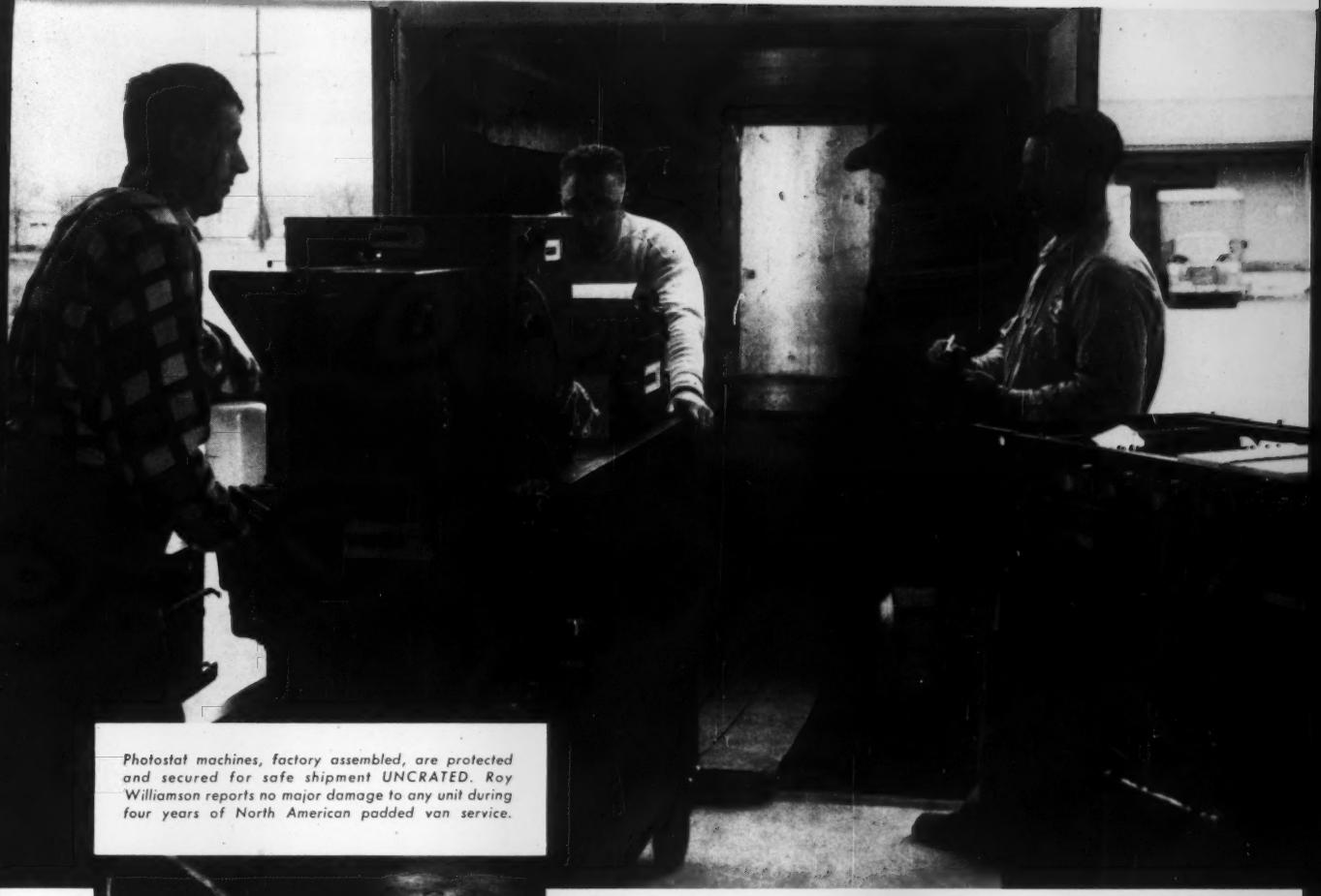
CONOFLOW CORPORATION

FOREMOST IN FINAL CONTROL ELEMENTS

Subsidiary of WALWORTH

CIRCLE 24 ON READER-SERVICE CARD

CIRCLE 25 ON READER-SERVICE CARD →



Photostat machines, factory assembled, are protected and secured for safe shipment UNCRATED. Roy Williamson reports no major damage to any unit during four years of North American padded van service.

How Photostat Corporation solved a problem... by shipping UNCRATED in NORTH AMERICAN VAN LINES' PADDED VANS

According to Roy Williamson, Traffic Manager for the Photostat Corporation, Rochester, New York, their problem was to make fast and safe delivery of factory-assembled photocopying machines—ready for use upon arrival.

North American Van Lines had the answer: ship the assembled machines UNCRATED in special padded vans. Delivery is made directly into the office where it is to be used—and a local Photostat representative quickly makes the few simple adjustments required. As a result, the customer is happy with a machine ready for use—and there are savings in both time and labor.

If *you* have a shipping problem, it will pay you to get the first-hand facts about North American Van Lines' padded van service. Write or phone today.

North American
WORLD-WIDE MOVING
LAND · SEA · AIR

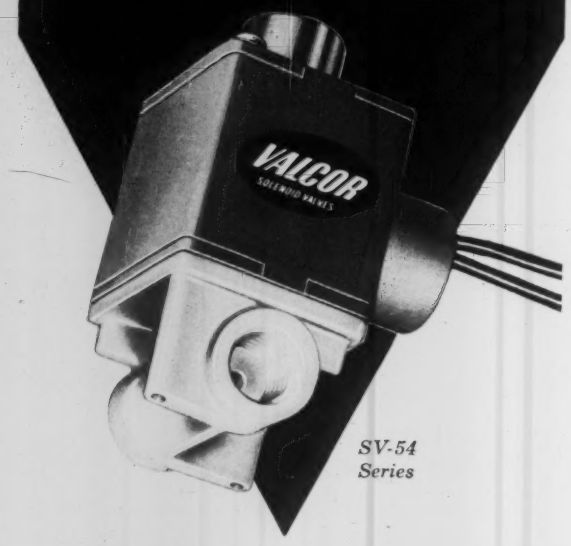
NORTH AMERICAN VAN LINES, Inc. / World Headquarters / Dept. 18-3 / Fort Wayne, Indiana
In Canada, North American Van Lines Canada, Ltd., Pickering, Ontario... In Europe, North American Van Lines Europe, GMBH, Mannheim, Germany

FILLED SYSTEM TEMPERATURE RECORDERS

New 3-Way Nylon-Body Solenoid Valve...List Priced as Low as $10.75...

(Quantity Discounts Available)

Outlasts, Outperforms Steel!



SV-54 Series

Valcor's new 3-way Nylon solenoid valve, SV-54 Series, outlasts and outperforms steel, yet is list priced as low as $10.75! In general purpose and O.E.M. installations, where millions of operating cycles are essential, this new Valcor valve not only works best but costs less.

Its nylon seat outlasts steel . . . its port threads outlast steel . . . pound for pound it's **3 times stronger than steel.** Dry seal threads, no compound is needed—and they won't loosen even under severe vibration. Nylon is non-corrosive so you have no atmospheric problems. And the hard stainless plunger is a workhorse for millions of cycles. Bubble tight sealing. Available in normally open, normally closed and "directional control" configurations in all normal AC and DC voltages . . . 1½" square x 3" long (valve illustrated).

Write today for complete technical data on this shock-resistant, pressure-proof valve—the 3-way nylon-body valve, SV-54 Series, that's 3 times stronger than steel, yet costs less. Try it on your toughest application.

VALCOR SOLENOID VALVES

VALCOR ENGINEERING CORP.

5366 Carnegie Avenue, Kenilworth, New Jersey

CIRCLE 26 ON READER-SERVICE CARD

stock report

Further information may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

NEW YORK STOCK EXCHANGE
PRICE RANGE FOR 1959 THRU July 15, 1959

	HIGH	LOW	PRICE AS OF 7/15/59
ACF Industries	56 1/4	47 5/8	52 1/2
Aeroquip Corp.	33 7/8	23 5/8	32 1/4
Allis Chalmers	34 1/4	26 7/8	32 3/4
American Chain & Cable	61	47 3/4	58 3/4
American Machine & Foundry	96	53 1/2	92
American Machine & Metals	59 3/4	41	51-51 1/4(1)
American Optical	53 1/2	38 3/8	51
American Tel. & Tel.	89	75 1/2	80 3/4
Ampex Corp.	84 1/2	61 1/4	77
Bausch & Lomb Optical	38 7/8	27	38 1/8
Beckman Instruments	74 3/4	36 1/4	60 1/4
Bell & Howell	74 3/8	58 1/2	70
Bendix Aviation	89	66	80 3/4
Boeing Airplane	46 1/2	34	35 3/8
Bullard	24 7/8	16	21 5/8
Bulova Watch	20 5/8	13 1/2	15 7/8
Burroughs	45 3/4	34 5/8	36 5/8
Carborundum	56 1/2	37 3/8	56 1/2
Cincinnati Milling Machine	47 5/8	38 3/4	43 1/8
Clevite	38 7/8	24 3/4	35 1/2
Columbia Broadcasting System	48 3/4	35	46 3/4
Consolidated Electrodynamics	42 5/8	33 3/4	39 1/2
Consolidated Electronics	50 1/8	33 1/2	49 7/8
Cornell Dubilier	30 1/2	20 3/4	26 1/4
Corning Glass	140	89 3/4	139 1/4
Curtiss Wright	39 1/2	27 1/8	35 3/4
Cutler-Hammer	91 3/4	59 1/2	86 1/2
Daystrom	49 3/4	34	42 5/8
Douglas Aircraft	59 3/4	45 1/8	47 3/4
Eastman Kodak	92 3/4	75	92 1/8
Eaton Mfg.	79 3/4	56 1/4	77 1/2
Electric Auto-Lite	50 3/8	36 1/4	49 5/8
Elgin Watch	14	9 3/4	11
Emerson Electric	69 7/8	48 1/8	67
Food Machinery & Chemical	52 3/4	41	49 1/2
Gamewell	39 1/4	27	30 1/4
Garrett	50 7/8	38	43 3/4
General Controls	39 1/4	24	32 1/2
General Dynamics	66 1/2	52 7/8	53 1/8
General Electric	84 3/4	74 1/8	82 1/4
General Instrument	38 3/8	16 1/2	29 1/4
General Mills	120 1/2	88 1/4	109
General Precision Equipment	45 1/2	31 1/2	41 3/8
General Railway Signal	39 1/4	33	36 3/8
General Tel. & Elec.	73 3/4	60	71 5/8
General Time	104 1/2	35	91 1/4
General Tire & Rubber	83	44 1/8	74 1/4
International Bus. Machines	488	385 1/2	443 1/2
International Tel. & Tel.	45 1/2	28	37 7/8
I-T-E Circuit Breaker	50 1/2	36 5/8	47 3/4
Litton Industries	126 1/2	72 5/8	124 5/8
Lockheed Aircraft	39 3/4	28 5/8	30 5/8
Magnavox	70	48 1/4	62 1/2
Mallory	48 3/4	36 3/8	43 1/8
Minneapolis-Honeywell	141 1/2	111 1/2	140
Minnesota Mining & Mfg.	151 1/2	111 1/2	148 3/4
Motorola	130	57 1/2	113
National Acme	63 1/2	52 1/4	60 3/4
National Cash Register	80	61	63 3/8
Neptune Meter	39 5/8	32 5/8	35 5/8
North American Aviation	52 5/8	39 1/4	47 1/4
Northrop Aircraft	44 3/4	31 1/4	34 1/4
Otis Elevator	82 1/4	61 1/2	80
Philco Corp.	36 3/4	21	29 7/8
Radio Corp. of America	71	43 1/8	69 1/4
Raytheon Mfg.	73 7/8	51 1/8	56 1/4
Reliance Electric	60 3/4	42 5/8	56 7/8
Rheem Mfg.	25 5/8	18	24 7/8
Robertshaw Fulton	53 7/8	31 5/8	53 3/8
Royal McBee	24 3/8	16	17 5/8
Sangamo Electric	51 1/2	35	41-42 (1)
Siegler Corp.	45 1/8	26 1/2	33 1/8
Sperry Rand	28 1/4	21 1/4	25 1/2
Square D	34 7/8	26 7/8	34
Standard Coil Products	23 3/4	14 3/8	18 5/8
Starret (L.S.)	23 7/8	20	23
Stewart-Warner	57 1/2	42 1/2	54 1/2
Telautograph	13 3/8	9	12 3/8
Texas Instruments	159 1/2	61 1/4	159
Thompson-Ramo-Wooldridge	70 1/4	56 1/4	66
Tung-Sol Electric	54 1/4	34 1/8	45
Underwood Corp.	30 7/8	20 5/8	28 1/2
Union Carbide Corp.	149 1/2	120 1/2	146 3/4
United Shoe Machinery	57 3/4	45 5/8	56 1/2
Western Union	43 1/2	29 3/4	42 7/8
Westinghouse Air Brake	38 1/2	32	35 1/4
Westinghouse Electric	98 3/8	70 1/2	94
Worthington Corp.	84 1/2	70 1/2	84 1/2

1) Not traded - Bid and Asked

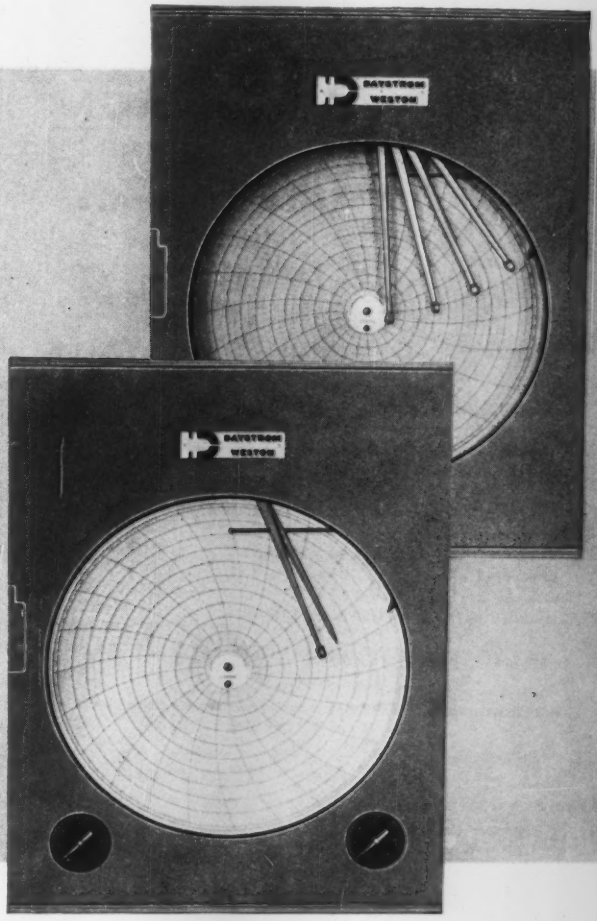
AMERICAN STOCK EXCHANGE
PRICE RANGE 1959 THRU July 15, 1959

	HIGH	LOW	PRICE AS OF 7/15/59
American Meter	45 1/4	38	43 1/2
Aro Equipment	29 3/4	22	24 1/2
Barry Controls "B"	26	13 3/4	23
Belock Instruments	22 7/8	10 3/8	19 3/4
Benrus Watch	9	5 7/8	8

Continued on page 1126

FILLED SYSTEM TEMPERATURE RECORDERS AND RECORDER-CONTROLLERS

Daystrom-Weston designs *New* VERSATILITY into these UNITIZED* temperature instruments



This new line of recorders and recorder-controllers covers the complete range of filled system instruments. Charts and ranges are available as low as –100° F. and as high as 1000° F. The series includes *Model 7811:* single pen recorder . . . *Model 7812:* multi-pen recorder *Model 7815:* single pen recorder-controller . . . *Model 7816:* two pen, two control unit . . . *Model 7817:* two pen, single control unit.

All models come in dust- and moisture-proof cases for universal mounting. Cases and internals are unusually clean in design, and provide easy accessibility. Pens have large capacities, rugged suspensions and automatic lifters. In addition, the series offers these important features:

- Interchangeable thermal systems — liquid-, vapor-, gas-, or mercury-filled.
- 12-inch charts, with 4.75-inch pen travel.
- Universal pneumatic controller may be used as a proportional . . . on-off . . . or differential gap controller.
- Proportional controller is available with reset — or reset and derivatives.
- Proportional band adjustability from 2 to 300%.
- Reset and derivative valves are adjustable from 0.02 to 5 minutes.
- Control setting and manual reset are simplified and easily accessible.

Circulars M-15-A and M-18-A contain full specifications. Contact your local Weston representative, or write to Weston Instruments, Division of Daystrom, Inc., Newark 12, N. J. *In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 10, Ont. Export: Daystrom Int'l., 100 Empire St., Newark 12, N. J.*

***UNITIZATION:** the grouping of related components—in Daystrom-Weston Industrial Instruments — in the simplest, most serviceable, most efficient manner.

DAYSTROM-WESTON

A DAYSTROM UNIT

Industrial Instruments

Visit us at Booth 403—14th annual I.S.A. Show—Sept. 21-25, Chicago, Ill.

CIRCLE 27 ON READER SERVICE CARD

MARSHALLTOWN

DIAPHRAGM GAUGE

FOR ACCURATE PRESSURE MEASUREMENT IN OUNCES OR INCHES OF WATER

Marshalltown Figure 83 is an extremely sensitive gauge that uses a carefully seasoned bronze diaphragm to accurately measure very low pressures. It is used extensively on many types of natural gas installations for checking low pressures.

Available in standard dials (reading in inches of water) 0-15" -0-30" -0-60" -0-100" -0-160" . . . also in ounce graduated dials from 15 ounces to 5 pounds. 2½", 3½" and 4½" dial sizes mounted in black enameled steel case.

Write for details and price. LOOK TO MARSHALLTOWN FOR ONE OE THE MOST COMPLETE LINES OF INDICATING PRESSURE GAUGES MADE!

MARSHALLTOWN MFG. COMPANY
MARSHALLTOWN 3, IOWA

CIRCLE 28 ON READER-SERVICE CARD

American Stock Exchange: *Continued from page 1124*

Breeze Corp.	9 3/8	6 1/4	7 1/8
Clark Controller	29 3/4	19 5/8	26 3/8
Clarostat Mfg.	10 1/4	4	8
Clary Corp.	10 7/8	5 3/4	8 3/8
DuMont Laboratories	9 7/8	6	8
Dynamics Corp. of America	12 3/4	4 5/8	9 7/8
Electronics Corp. of America	16 7/8	9 1/2	11 1/4
El-Tronics	2 1/4	1	1 1/4
Fairchild Camera & Instrument	205	50 3/4	195
General Transistor	88 1/4	49	85 3/4
Globe-Union	27 3/4	20 1/4	26 3/8
Hazeltine Corp.	33	28 1/2	30 1/2
International Resistance	22 3/4	7	18 7/8
Lear Inc.	19 1/4	9 1/8	15 3/4
National Research	39 1/2	15 3/8	28 3/4
New Haven Clock	5 3/8	1 1/2	3 1/8
Nuclear Corp. of America	4 1/4	1 3/4	2 3/8
Philips Electronics, Inc.	50 1/4	23 1/2	49 1/2
Pneumatic Scale	67	32	49 1/2
Servo Corp. of America	43 1/2	14 5/8	32 1/8
Servomechanisms	18 1/4	9	13 1/8
Statham Instruments Inc.	43	23	30 7/8
Victoreen Instrument Co.	19 7/8	6 7/8	16
Wallace & Tiernan	51	36 1/4	50
Waltham Prec. Instrument Co.	4 3/8	1 1/8	2 7/8

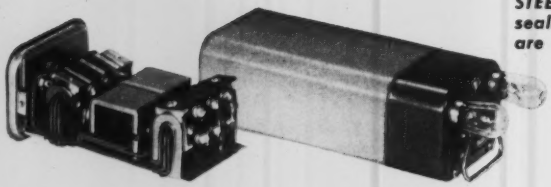
OVER THE COUNTER

	QUOTATION AS OF 7/15/59 BID	ASKED
Aerovox Corp.	11 1/4	13 1/8
Aircraft Radio Corp.	50 1/2	--
Argus Corp.	42 3/4	43 1/2
Black Sivalls & Bryson Inc.	22 1/2	23 1/4
Eitel McCullough	43 1/4	44 1/4
Electro Instruments	34 1/4	35 1/2
Electronics Associates	41 1/2	43
Erie Resistor Corp.	9 3/8	10
Fisher Governor Co.	19 1/2	21
Foxboro Company	48	50
Ginnini Controls	29 1/2	30 3/4
Hagen Chemicals & Controls	29 1/2	30 1/2
Industro Transistor	6 1/2	6 7/8
Liquidometer Corp.	7 3/4	8 1/2
W. L. Maxson	10 1/8	11 1/4
Penn Controls	25	26
Speer Carbon, Inc.	45	46 1/2
Sprague Electric	54	56
Taylor Instruments	33	34 1/2
Telecomputing Corp.	10 3/8	11
Topp Industries	13 5/8	14 1/8
Varian Associates	33 1/2	34 3/4
Vitro Corp. of America	16 1/4	16 3/4

The Most Important Annunciator Advancement in Years!

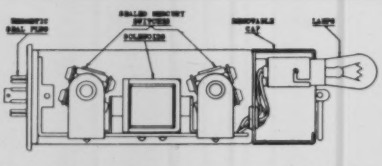
MERC-ALARM ANNUNCIATORS

NEW ALL-MERCURY ANNUNCIATORS



STEEL-CLAD unbreakable sealed mercury switches are used exclusively in all annunciator circuits. RUGGED — SAFE — DEPENDABLE!

The MERC-ALARM standardized plug-in units, with simplified components require a minimum of servicing. All parts are fully accessible for easy maintenance.



An exclusive solenoid-operated tilting mechanism eliminates "Wire Fatigue" assuring long life operation with a minimum of moving parts. Silent mercury contact switches are entirely hermetically sealed.

The all-mercury annunciators are actuated by sealed mercury switches which offer positive high current interrupters and since all of the contacts are hermetically sealed they automatically meet Class 1, Division 2 safety requirements. Dirt, dust, moisture and temperature changes cannot affect their operation.

For complete safe operation, Acknowledging, Reset and Test push-buttons are available in fully sealed mercury units for use in conjunction with the All-Mercury annunciator system.

MODEL 400-M UNITIZED ANNUNCIATOR CABINETS can be made up in any multiples. Hinged door permits access to lamps, plug-in units and chassis. Terminals are in roomy rear wiring compartment or may be reached from the front if needed.

MERCURY FLASHER...Where a flashing sequence is required, a heavy-duty mercury-actuated flasher unit is used which makes it feasible to use only one flasher for as many as 500 alarm units.

FOR FULL INFORMATION REQUEST BULLETIN 440

Tigerman Engineering COMPANY
4332 North Western Avenue
Chicago 18, Illinois

CIRCLE 29 ON READER-SERVICE CARD

CIRCLE 30 ON READER SERVICE CARD →

THE NEW

SLO-SYN

SYNCHRONOUS MOTORS

AUTOMATIC MACHINES AND APPARATUS
needing a simple, efficient, maintenance-free synchronous motor

NUMERICAL CONTROL SYSTEMS
requiring continuous, constant-speed traverse and/or incremental stepping for positioning

REMOTE CONTROL SYSTEMS
using either manually-operated or remote positioning control

SERVOMECHANISMS
calling for instant starting, stopping and reversing characteristics without slip or chatter

72 RPM shaft speed!

STARTS instantly!

REVERSES instantly!

STOPS instantly!

can be used as a stepping motor!

THE
SUPERIOR ELECTRIC
COMPANY

Bristol, Connecticut, U.S.A.

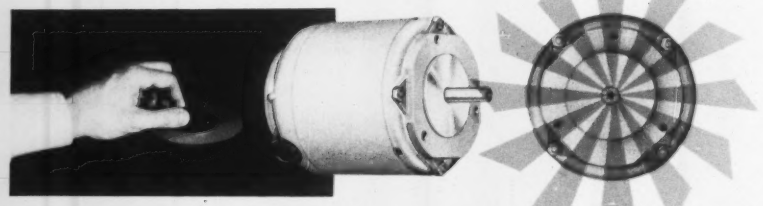
slo-syn SYNCHRONOUS MOTORS

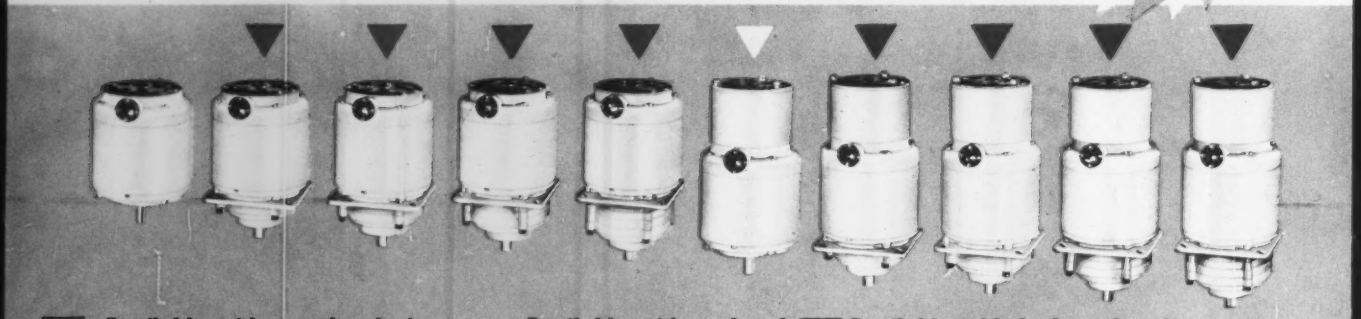
A SLO-SYN is an enclosed, permanent magnet type a-c motor with a slow basic shaft speed of 72 RPM. A single-pole, three-position switch can give complete forward, reverse and "off" control because the motor has three leads only. The SLO-SYN Motor will start or stop in less than 0.025 seconds or approximately 1.5 cycles. No need for electrical or mechanical braking because the motor will stop in less than 5° of shaft rotation. Maximum moment of inertia of a load rigidly attached to the shaft is 1.5 pound-inches². Loads with higher inertia can be started by using a coupling method which allows 5° freedom. Types having specially-designed planetary gear assemblies are available to provide speeds of 3.323, 0.665, 0.133 or 0.027 RPM. Torque on all planetary gear types is 2500 ounce-inches.

TYPE SS150

AS A D-C STEPPING MOTOR

The SLO-SYN Synchronous Motor can be adapted for use as an incremental stepping device by the use of a d-c power source and a suitable switching arrangement. When used as a control system stepping or "inching" motor, d-c electrical impulses are converted into either 200 or 400 precise increments of one revolution of the motor shaft. The motor will maintain its rated torque for any stepping position. Each step is made instantly without slip or clatter because no ratchets are used.





▼ **Available with speed reducing planetary gears**

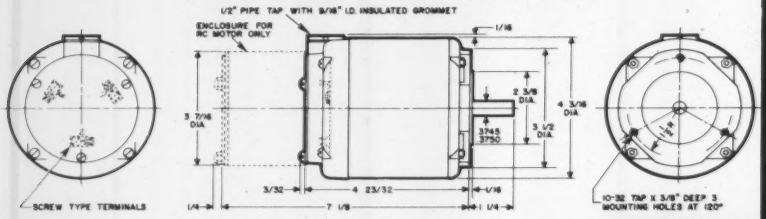
▽ **Available with enclosed capacitor and resistor**

▼ **Available with both enclosed capacitor and resistor and planetary gears**

RATINGS AND SPECIFICATIONS

INPUT	120 volts, 40/70 cycles, 1 phase
OUTPUT SPEED	72 RPM at 60 cycles
MAX. CURRENT	0.3 ampere at 60 cycles
TORQUE	150 ounce-inches
WEIGHT	6.5 pounds

OUTLINE DIMENSIONS – TYPE SS150



THE SUPERIOR ELECTRIC COMPANY, Bristol, Connecticut

☐ Please send SLO-SYN Synchronous Motor Bulletin

☐ Please have your representative call.

name

company

address

city zone state

. . . FOR YOUR FILES

Request SLO-SYN Bulletin giving full technical information, ratings and specifications.

THE SUPERIOR ELECTRIC COMPANY

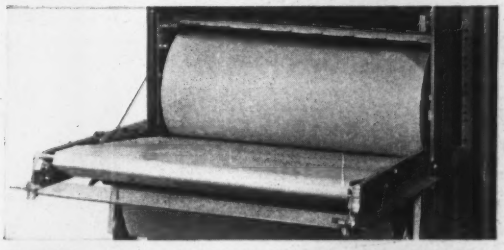
Bristol, Connecticut, U.S.A.

Testing Slated for Courier Satellite

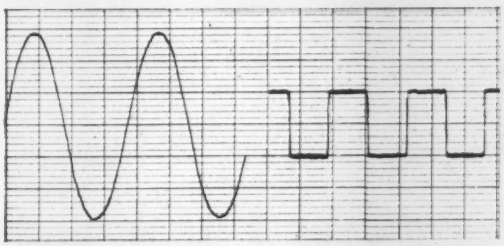
the most versatile . . . most sensitive direct writing unit available!

OFFNER ALL-TRANSISTOR R DYNOGRAPH

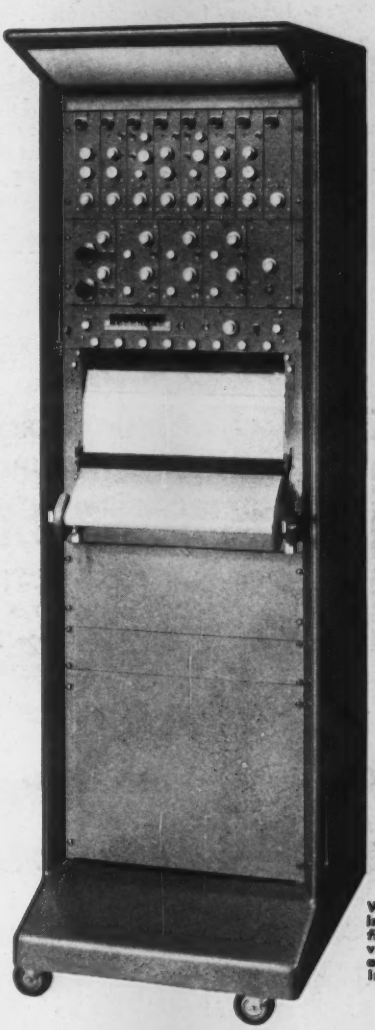
The Type 481 preamplifier, 9800 series input coupler, 482 power amplifier, and 382 power supply are all of plug-in construction. Input is available both front and rear.



The 504A paper drive gives speeds of from 1 to 250 mm/sec. Electrical speed shift 1 to 250 mm per minute available. Zero weave high precision drive, 850 ft. capacity (heat or electric) 1500 ft. (ink). Front loading, with record fully visible from front.



Full scale, unretouched charts show the extreme sensitivity of the Type R Dynograph. Left—10 microvolt RMS sine wave. Right—10 microvolt D-C square wave. Four recording media. Heat or electric rectilinear—ink or electric curvilinear. Readily convertible.



We have a few openings for highly qualified engineers in development, production, and sales engineering. Inquiries are invited.

all these features... plus 8 channels in only 35″ of rack space

- stable d-c sensitivity of one microvolt per mm
- true differential input
- high input impedance
- response to beyond 150 cps
- reluctance, differential transformer, strain gages with a-c or d-c excitation, thermocouples, etc., used with all preamplifiers
- deflection time less than 1.5 milliseconds (2.5 ms with preamplifiers)
- fixed precision calibration
- instant warm-up
- precision source for d-c and 400 cycle excitation, self-contained
- zero suppression, twenty times full scale, both directions

Whatever your application for direct writing records, investigate the ability of the Offner Type R Dynograph to do the job *better* and more *simply*. Write on your company letterhead for details and specifications.

OFFNER ELECTRONICS INC. 3910 River Road, Schiller Park, Ill. (Suburb of Chicago)

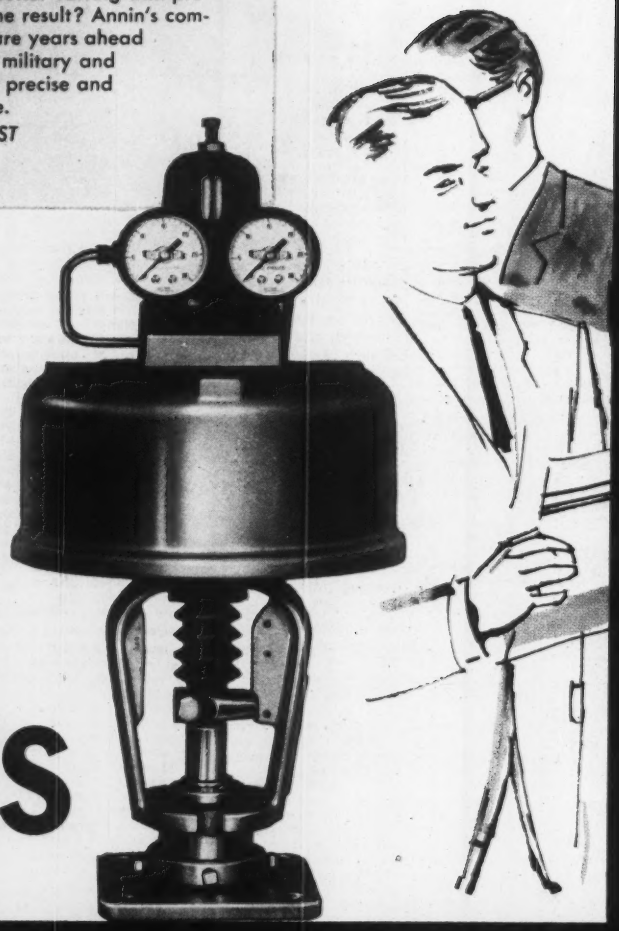
← CIRCLE 30 ON READER-SERVICE CARD

CIRCLE 31 ON READER-SERVICE CARD

Take Look into Industry's Future

Wherever control engineers gather, Annin Valves are the center of attraction ... Annin features the most talked about. In the development of Annin Valve bodies and actuators, Annin engineers anticipated the exacting demands of today's technology for new concepts ... new high standards of performance ... in fluid flow control. They foresaw the requirements for superior valving with precision positioning and dynamic response characteristics. The result? Annin's complete line of bodies and actuators, like those shown here, are years ahead of the industry. As new headlines tell of new advances in military and industrial automation, Annin is ready to meet the need for precise and powerful control elements with the finest designs available.

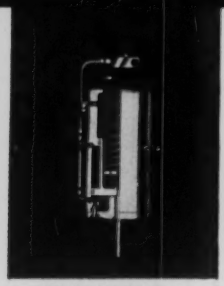
Write today for Annin's latest Actuator Bulletin No. 1236ST



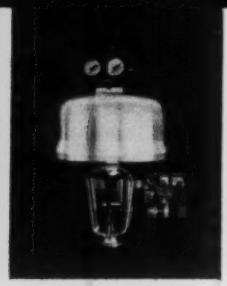
SPACE AGE AUTOMATION REQUIRES THE PRECISE POSITIONING AND DYNAMIC RESPONSE OF

Annin VALVE ACTUATORS

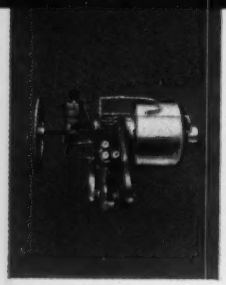
ON DISPLAY AT THE 14TH ANNUAL ISA INSTRUMENT —



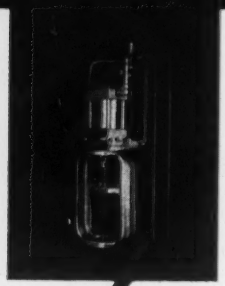
600 Series Actuator



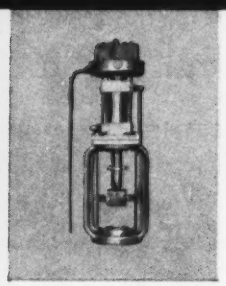
Electro Pneumatic . Domotor Actuator



Toggle Actuator



Pneumatic Hydraulic Actuator



Electro Hydraulic Actuator

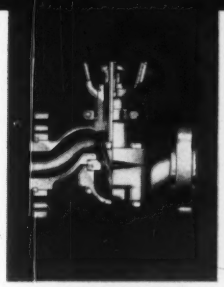
THE ANNIN COMPANY *Annin*

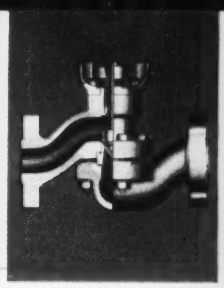
CIRCLE 32 ON READER-SERVICE CARD

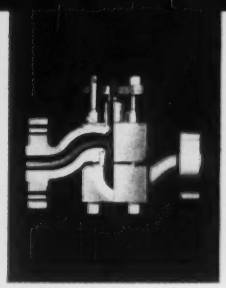
THE MOST ADVANCED FEATURES
IN MODERN VALVE DESIGN
ARE COMBINED IN

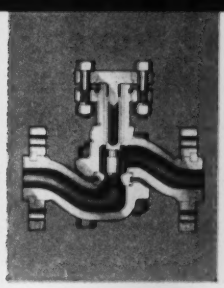
Annin
VALVE
BODIES

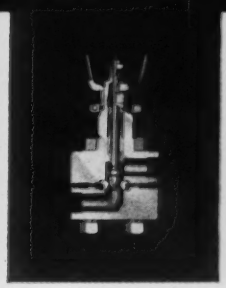
— AUTOMATION CONFERENCE AND EXHIBIT...BOOTH 454


15 Group Body
600 lb. ASA rating


45 Group Body
1500 lb. ASA rating


65 Group Body
2500 lb. ASA rating


Check Valve Body
600 to 2500 lb. ASA ratings


34 Group Body
2500 and 10000 lb. ratings

VALVES

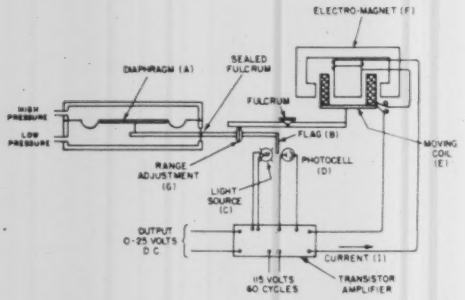
THE ANNIN COMPANY
1040 S. Vail Avenue, Montebello, California

CIRCLE 32 ON READER-SERVICE CARD

briefs

Electric Flow Transmitter Has Linear Output

Differential pressure applied to diaphragm (A) moves flag (B) between the light source (C) and the photocell (D). The signal from the photocell varies in strength according to the flag position, and is fed to the transistor amplifier. The amplifier output consists of a d-c current and the moving coil (E) and



the electromagnet coil (F). The moving coil is attracted by the magnetic field of the electro-magnet with a force proportional to the square of the current. This force is transmitted through the balance arm to the range adjusting wheel (G), which bears on the lever arm and balances the force exerted on the lever arm by the diaphragm (A). Differential pressure at the diaphragm is measured by the square of the current. The current is therefore a direct measure of flow rate . . . (*From new* 54-*page General Catalog, GPE Controls, Inc.*, 240 *East Ontario St., Chicago* 11, *Ill.*)

FOR THIS LITERATURE CIRCLE 190 ON READER SERVICE CARD

Alphanumeric Printer Prints 48,000 Digits/Sec

The Potter Model 3260 Alphanumeric Printer is an integrally housed drum type printer and electronic storage and control system which . . . can be connected to many data producting devices . . . Data can be accepted from any source of digital information—such as digitizers, magnetic or perforated tapes, electronic counters or computers. A printout rate of 48,000 digits per second is possible . . . As a logger of digitized data from a series of analog to digital converters a scan and printout rate of 200 3-digit numbers is realizable . . . (*From new* 2-*page News Release PICO* 1014, *Potter Instrument Co., Inc., Plainview, N. Y.*)

FOR THIS LITERATURE CIRCLE 191 ON READER SERVICE CARD

Electronic Computing Systems in the Petroleoum Industry

Today Burroughs computing systems are being employed by hundreds of petroleum and petrochemical engineers and businessmen in determining optimum material blends, speeding accounting, providing better management reports, simulating refinery operations, ordering materials, selecting crudes for refinery runs, designing equipment and piping, scheduling startup and shutdown procedures, and providing many other data processing services . . . Installed since 1955, a Burroughs 205 computer system at Magnolia Petroleum Co. in Dallas has been solving exploration and production research problems . . .

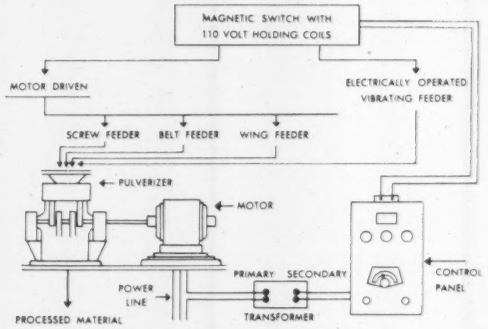
Socony Mobil in Paulsboro, New Jersey, acquired their system in 1954. With two magnetic tape units, automatic floating point and a punched-card system, the Burroughs 205—nicknamed "Mobilac"—is also involved in production and transportation calculations.

One of the first jobs of the Burroughs computer at Socony was refinery simulation. The computer had to simulate in appropriate mathematical form such operations as catalytic cracking, reforming, alkylation, octane and vapor pressure blending and tetraethyl lead addition . . . In the petrochemical field, Celanese Corporation of America uses their Burroughs 205 system for mass spectrometer analysis—as well as in some dozen other applications . . . (*From new* 16-*page Bulletin* 3214, *Burroughs Corp., Electrodata Div., Pasadena, Calif.*)

FOR THIS LITERATURE CIRCLE 192 ON READER SERVICE CARD

Electronic Feed Regulator

Electronic feed regulator can be applied to any type of processing equipment in which the load in the machine is directly or proportionately reflected in the motor operating the machine . . . Its load range regulator takes a signal from the load on the motor



operating the grinding or pulverizing equipment. When the load rises above the predetermined maximum level, the feed is momentarily shut down. The machine continues to unload until the load falls a few percent below the desired maximum at which time the feed starts again automatically . . . (*From new* 6-*page Bulletin* 13552*D*, *Industrial Instruments Inc.*, 89 *Commerce Rd., Cedar Grove, N. J.*)

FOR THIS LITERATURE CIRCLE 193 ON READER SERVICE CARD

Engineered Dehydration in Pneumatic Systems

- 35° F. dew point at pressure
- Mag-Pneu-Power Trap
- Medicine for missile ill

Don't worry about dew point

That's a silhouette view of our new Hankison REFRIGIFILTER that protects pneumatically-operated equipment from all forms of moisture, oil, and contaminants. It's designed for use where cooling water is not available or where there's a great variance in ambient temperatures. Delivers a dew point of 35°F at pressure.

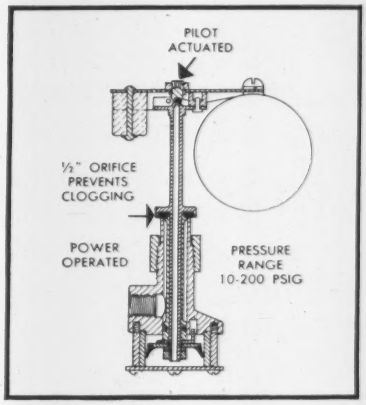
In September, ISA showgoers will get industry's first clear look at the REFRIGIFILTER. They'll see a compact "package" combining a condenser, filter cartridge, heat exchanger, refrigerating section and automatic trap. For the first time, industry can have, in one integrated unit (1) accurate and continuous flow and control of coolant, plus (2) ultra-efficient filtering and dehydration action that removes over 90% of moisture/oil vapors, and all entrained liquids from compressed air and gases.

The remarkable REFRIGIFILTER will be demonstrated in Booth 663 at the ISA Show, September 21-25. Don't miss it! (If you're not going to the show send in the coupon attached and we'll send you full information.)

A well-planned trap

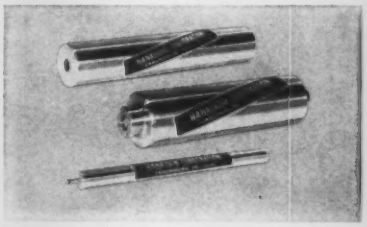
Looking for a non-clogging trap? Note the drawing of the mechanism in our Mag-Pneu-Power Trap. Rising condensate pushes against the magnetically-held float until it snaps free. Pressure in the pneumatic system then drives the piston, which opens the discharge valve. Condensate is discharged in a split second through the large ½" orifice. It's simple – and trouble-free. For the occasional cleaning that's required, just open the blowdown petcock in case (not shown).

Mag-Pneu-Power Traps are used to discharge condensates and entrainments from all types of compressed air and gas lines, and to lend valuable assistance to air and gas dehydrating equipment. Stainless steel models are available for corrosive applications.



Missile thrombosis

Certain missile guidance systems depend on maintained cryogenic temperatures to assure sensitivity of infra-red detector cells. Temperatures as low as −320°F are held by expanding "dry" nitrogen from above 1000 psig to one atmosphere, regulating it through minute orifices. It's a delicate function—if you had what the missile can get when oil, moisture, or particles clog these orifices, the diagnosis would be thrombosis.



Keeping the tiny orifices clear is a big problem; solving it may mean the difference between success and failure of a missile design. Specially-designed Hankison Missile Dryers – through which the nitrogen passes – are the answer. They are effective to the adsorption of 200 grains of water, keep the nitrogen free of any contaminants or entrainments that could clog the all-important orifices.

You may not make missiles, but if you've small orifices to safeguard, HANKISON can help you.

HANKISON CORPORATION, COLLEGE & PIKE, CANONSBURG, PA.

There's something here that interests me. Please send me more information about

- ☐ Hankison Refrigifilters
- ☐ Mag-Pneu-Power Automatic Traps
- ☐ Missile Dryers

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COMPANY _____

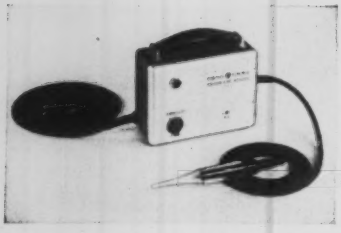
STREET _____

CITY _____ ZONE _____ STATE _____

Hankison

CIRCLE 33 ON READER-SERVICE CARD

locates leaks in a flash . . .



This new General Electric Type H-6 leak detector flashes a probe light instantly when the tip pinpoints a leak. Air conditioning and refrigeration leaks (even as small as ½ ounce per year) are detected quickly and positively in a flash! ***Eliminates costly guess work.*** As soon as the tip of the probe finds a broken seam or leaky joint, there's a reliable signal right in your hand! The H-6 has an automatic balance circuit . . . you can locate leaks even when the atmosphere is contaminated with refrigerants up to 100 ppm. Flip the switch and start probing in only 60 seconds. This sensitive unit ***responds to leaks quickly,*** recovers in a second. It's compact, lightweight, rugged, portable . . . and attractively designed. Always enjoy fast, positive, sensitive detection—at low cost—with the Type H-6. Or, for other special applications, select from General Electric's complete line of portable and stationary halogen units for pressure or vacuum leak testing. Get the full story today! Just contact your local air conditioning and refrigeration wholesaler, or write direct to Sect. 595-203, General Electric Co., Schenectady 5, N. Y.

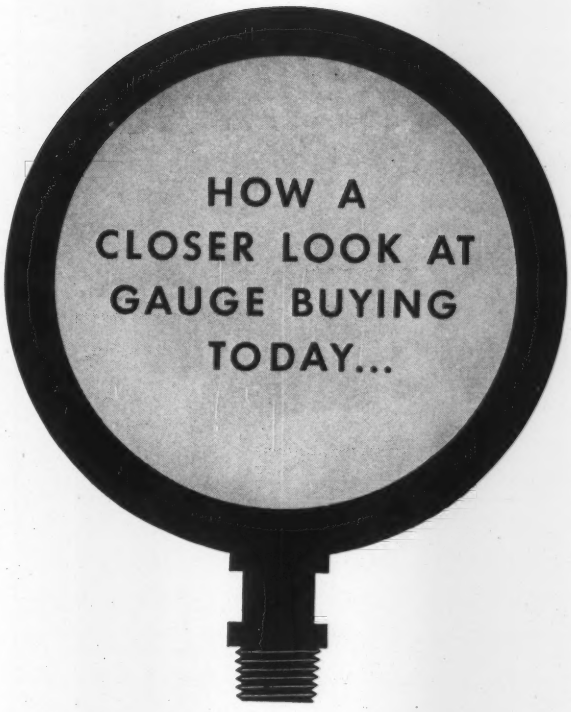
See the latest additions to General Electric's complete line of leak detectors, a revolutionary new industrial mass flowmeter and other G-E instruments at the ISA Instrument-Automation Exhibit in Chicago's Amphitheatre, Booth Number 414, September 21–25.

Other General Electric Instruments for Industry—*Hook-on voltammeters, electric recorders and controllers, pyrometers, timing devices, speed and color measurement equipment, laboratory test instruments.*

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

CIRCLE 75 ON READER-SERVICE CARD



can save up to 40% on many pressure gauge applications

Analyzed your gauge needs lately—how much gauge performance you're getting, compared to what you need and what you pay for? Perhaps it's time for a closer look at United States Gauge with its line of 50,000 standard pressure gauges, plus specials (and all possible choices in case styles, sizes, materials and pressure ranges). For example, note how you can save up to 40% on premium gauges and still get premium performance with the USG A-Line *(top, right)*. Note, too, how you can get the exact gauge for *any* need and cut waste of under-buying or "over-gauging" . . . from all the gauge lines available at this one source. Then check the USG distributor listed in your Yellow Pages. Or write direct for catalogs and name of your nearest distributor today.

Paying needless premium prices for reliability? USG A-Line pressure gauges have premium construction, save up to 40% on premium prices. Meet A.S.A. Grade A standards, including 1% accuracy. Extra rugged, they are built to *deliver* longer under severe operating conditions, where you do not require the accuracy of Grade AA gauges, but where reliability and cost-cutting are "musts". Wide choice of Bourdon tubes, case styles and sizes, pressure ranges, and movements. You must see the sturdy design and price to believe the value and performance. Models for general-purpose service, altitude, refrigeration, ammonia and hydraulic applications. *Write for Catalog 305.*

Buying too much gauge for your purpose? Save with volume-priced, precision-built USG Drawn Case Gauges for service where your gauge need calls for A.S.A. Grade B standards, including 2% accuracy. *Write for Catalog 64A.*

Getting all the accuracy you're paying for? You can't buy more precision than with USG Test Gauges which meet or exceed A.S.A. Grade AA standards, including accuracy as high as 0.2 of 1%. *Write for Catalog 400.*

UNITED STATES GAUGE
Division of American Machine & Metals, Inc., Sellersville, Pa.

Find Your Nearest Distributor in the 'Yellow Pages'

CIRCLE 35 ON READER-SERVICE CARD

...the *Spotlight* is on

P.O.P. (Pneumatic Operated Pistons)

All sizes including spring return and manual operator models.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY . . .

CIRCLE 44 ON READER-SERVICE CARD

FISHER at the

International ISA *Show*

SEE AND OPERATE THESE

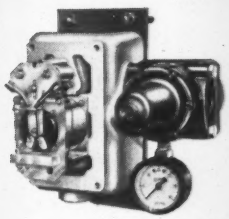
FISHER DEVELOPMENTS

AT BOOTH 210-213

INTERNATIONAL AMPHITHEATRE

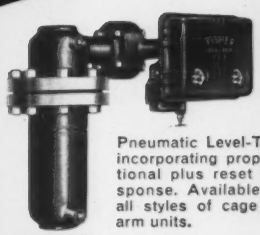
CHICAGO SEPT. 21-25

Type 543



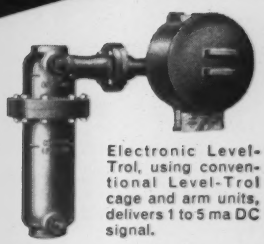
Electro pneumatic transducer

Type 2502 Level-Trol with reset



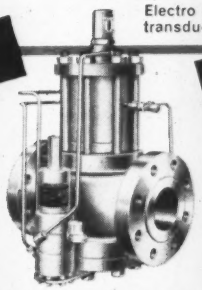
Pneumatic Level-Trol incorporating proportional plus reset response. Available in all styles of cage or arm units.

Type 2300-249



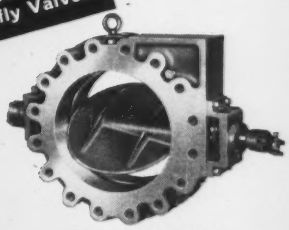
Electronic Level-Trol, using conventional Level-Trol cage and arm units, delivers 1 to 5 ma DC signal.

Type 403

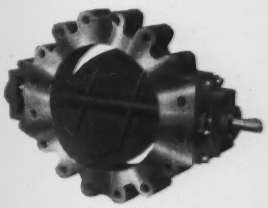


Revolutionary new high-pressure gas regulator

Fisher-Continental Butterfly Valves



Fisher-Continental Butterfly Valves



For heavy duty service—available in seven classes of construction.

FISHER® Controls

SINCE 1880

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

BUTTERFLY VALVE DIVISION CONTINENTAL EQUIPMENT CO., CORAOPOLIS, PENNSYLVANIA

CIRCLE 44 ON READER-SERVICE CARD

THERMOCOUPLES FOR DIFFICULT MEASUREMENTS SUCH AS

traveling tunnel kilns

special test equipment

oil refinery heater tubes

metal surfaces (magnetic)

diesel engine applications

in-motion measurements

and others

Bristol's Armorox thermocouple is good for temperatures up to 2000°F and at pressures to 50,000 psi.

Metal-sheathed, tightly packed with refractory insulation, Armorox is flexible. It bends easily around twice its own diameter to get into out of the way places.

Bulletin P1281 gives full facts on Armorox. Complete line of Bristol Thermocouples is described in Bulletin P1238. Write: The Bristol Company, 154 Bristol Road, Waterbury 20, Conn.

8.45

Thermocouple Wires
Iron-constantan
Copper-constantan*
Chromel-Alumel

Standard Sheath Materials
304 Stainless • Inconel†

Thermocouple Heads
Standard small head
Plug and jack head with screw lock
Permanent head

Standard Diameters (OD)
1/16", 1/8", 3/16", 1/4"

*T.M. Reg. by Hoskins Mfg. Co.
†T.M. Reg. by International Nickel Co.

BRISTOL TRAIL-BLAZERS IN PROCESS AUTOMATION

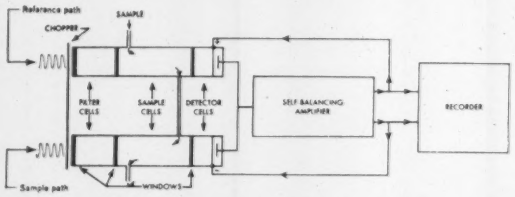
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

CIRCLE 38 ON READER-SERVICE CARD

BRIEFS—CONTINUED

Infrared Analyzer Utilizes Intra-Molecular Resonance

When infrared radiation—heat—passes through a liquid or gas, a portion of the radiant energy is absorbed. With many gases and liquids there is a phenomenon of intra-molecular resonance by which the radiation is strongly and selectively absorbed at wave-

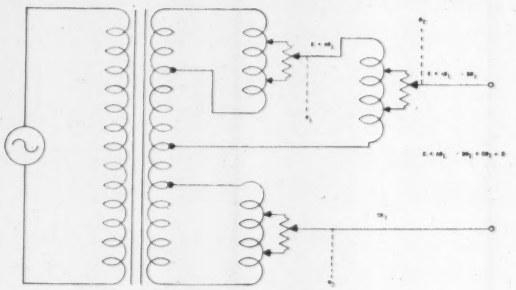


lengths corresponding to the molecular resonance frequencies. This results in a characteristic absorption spectrum for each gas or liquid. This spectrum is a unique characteristic of the substance just as a fingerprint is unique. The Series 700 uses this unique property to monitor one out of a mixture of gases or *liquids . . . (From new 4-page Bulletin 700, Analytic Systems Co., 980 North Fair Oaks Ave., Pasadena, Calif.)*

FOR THIS LITERATURE CIRCLE 197 ON READER SERVICE CARD

Vernistat A-C Potentiometer

With an output impedance of only 40 ohms and a terminal linearity of ±.01%, the Model 3B Vernistat a-c Potentiometer represents a major advance in the technique of relating shaft position to voltage . . . Like other Vernistats, the Model 3B combines the low output impedance and high accuracy of a tapped auto-



I. $[K + A(\Theta_1)] \bullet B(\Theta_2) + C(\Theta_3) = D$

transformer with the high resolution of a precision potentiometer. The accuracy of this combination is further improved by utilizing 30 shaft turns to traverse the entire output voltage range . . . Multiplication and addition are easily performed without the use of amplifiers. The low output impedance may be used to advantage in directly exciting resolvers . . . *(From new 2-page Technical Data 3B (30-turn), Vernistat Div., The Perkin-Elmer Corp., Main Ave., Norwalk, Conn.)*

FOR THIS LITERATURE CIRCLE 198 ON READER SERVICE CARD

NEW BAILEY
Multi-Pointer Gage

...has twice as many indicators
...no taller than a telephone!

Now the popular versatile Bailey Multi-Pointer Gage has been reduced in size to conserve control panel space—without loss of easy *readability*.

Each new Multi-Pointer Gage Unit offers you these three choices to—

1. Measure and indicate draft, pressure, differential pressure and level.
2. Transmit above variables either pneumatically or electrically to remote indicators, recorders and/or controllers.
3. Receive and indicate any measured variables which may be transmitted pneumatically by standard SAMA ranges of 3-15 psig. or 3-27 psig.

FEATURES

Compact Size—Two large, easily-read 7″ scales in space only 4 inches wide.

Wide Range Selection—Standard ranges from 0-0.5 in. H_2O to 0-5000 psig available.

Choice of Standard Colors—Satin Black, Slate Gray, Moss Green, or Terra Tan may be selected as an exterior color at no additional cost.

Colored Scales—Scales available in white, red, green, blue, yellow, or orange.

Fluorescent Illumination—All gages have slideout unit containing bulb and starter for ease of maintenance.

Readily Accessible Adjustments—Zero adjustment made from front of gage. Other adjustments made from rear of gage.

Two-point Positive Mounting—Gage unit mounted with two clips . . . no holes to drill or studs to weld.

Unlimited Indications—Any number of basic two-indicator units may be placed side-by-side to provide indications of related factors. Each two-indicator unit is separately mounted.

For additional information, call your local Bailey District Office, or write us direct. G47-1

Instruments and controls for power and process

BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

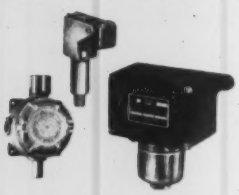
CIRCLE 39 ON READER-SERVICE CARD

CONFIDENCE

where control

counts

Pressure-Vacuum Controls for Industrial, Aircraft, Marine, Special Purpose



APPLICATIONS: Unlimited. For 28 years, we have been designing and manufacturing controls to fit individual needs.

MEDIUM: Air, gas or liquid.

RANGE: 30"hg vac to 1700 PSI.

SENSITIVITY: 3/4 ± 1/10" W.C. and up.

SWITCHES: Normally closed, open or double throw. Manual reset, high ambient and others available. 15 or 20 amps. 115/250 Volts AC. Also DC.

TYPES: Skeleton or enclosed, calibrated or uncalibrated, single or multi-switch, minimum size and weight, differential pressure, absolute pressure, super-sensitive, shock-proof, explosion-proof and others.

OPERATION: Precision-made bellows combine with full rated snap-action switches for quick accurate response to pressure or vacuum change.

For further information request Condensed Catalog #500.

UNITED ELECTRIC

CONTROLS COMPANY

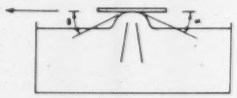
88 School St., Watertown, Mass.

CIRCLE 40 ON READER-SERVICE CARD

BRIEFS—CONTINUED

Automated Soldering Boosts Production Speeds

The heart of Electrovert's system is Fry's Flowsolder machine which raises the molten solder from the solder bath to the bottom surface of the assembly. Solder is forced, by means of an impeller pump, through an elongated nozzle so that it forms a stand-

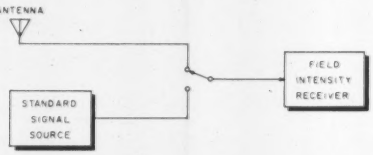


ing laminar wave. The height of this dross- and oxide-free wave is easily regulated and maintained within the limits of ±1/32" by adjusting pump speed. Temperature of the solder wave is kept constant within the range of ±1°F by thermostatic control. Angled entry and exit, necessary to release air, flux vapors and gases, is provided by the shape of the solder wave. Reject rates have been reduced to approximately 0.1% with this system . . . (*From new 4-page bulletin "Fry's Flowsolder Method," Electrovert Inc., 124 East 40th St., New York 16, N. Y.*)

FOR THIS LITERATURE CIRCLE 199 ON READER SERVICE CARD

Calibration of Field Intensity Receivers

Field intensity meters can be calibrated either directly, by means of a power measuring element, or by signal substitution . . . Figure is a block diagram of field intensity receiver calibration by signal substitution . . . Three instruments are used to produce the standard signal for field intensity receiver calibration by the substitution method. They are the impulse generator, the noise generator, and the signal generator . . .

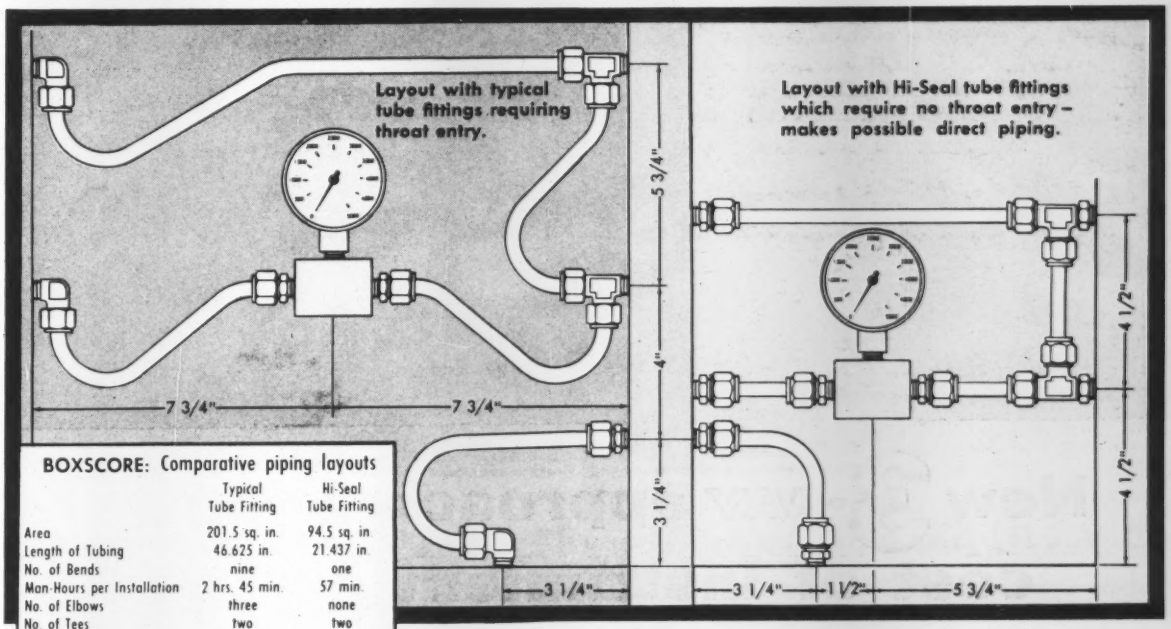


A signal generator is an instrument which produces a known and controllable radio frequency signal . . . The output of a signal generator is a minimum of one milliwatt calibrated power. This corresponds to 220,000 microvolt per megacycle or 0 dbm per megacycle, for a receiver with an impulse bandwidth of one megacycle. Therefore, the signal generator can be used as a substitution device over a very wide dynamic range . . . Calibration is direct when using a signal generator if the interference which is to be measured by the receiver is narrow band or if a peak value of pulsed-cw interference is to be determined.—(*From new 4-page issue of "Instrumentation," Vol. 4/No. 1, Polarad Electronics Corp., 43-20—34th St., Long Island City 1, N. Y.*)

FOR THIS LITERATURE CIRCLE 200 ON READER SERVICE CARD

IMPERIAL *Engineering and Data File*

ENGINEERED TUBE FITTINGS — VALVES — TUBING TOOLS



BOXSCORE: Comparative piping layouts

	Typical Tube Fitting	Hi-Seal Tube Fitting
Area	201.5 sq. in.	94.5 sq. in.
Length of Tubing	46.625 in.	21.437 in.
No. of Bends	nine	one
Man-Hours per Installation	2 hrs. 45 min.	57 min.
No. of Elbows	three	none
No. of Tees	two	two
No. of Straights	three	six

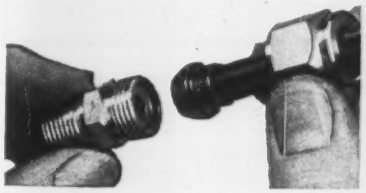
How Hi-Seal saves space—cuts costs

. . . makes possible reductions up to 50% in required piping area . . . up to 66⅔% in installation time!

Imperial Hi-Seal tube fittings open up economical *new piping design concepts* for instrumentation, hydraulic circuits, and other tubing installations. Hi-Seal makes possible far more compact layouts than can be made with conventional fittings — in addition, it brings *new ease and speed* to joint making and utmost reliability.

These design considerations are illustrated in the tubing layouts above. The diagrams show how Hi-Seal actually eliminated nine tube bends . . . saved more than one-half on tubing needed. Total layout area required by Hi-Seal is only 94.5 sq. in., compared to 201.5 sq. in., when an ordinary fitting is used. And 189% *more* manhours were required to tube up the circuit with a typical fitting.

Several key fitting design factors account for Hi-Seal piping economies: (1) Hi-Seal makes a positive butt joint — no need to spring tubing; (2) speedy, foolproof assembly — it is impossible for the fitting to be assembled with the alloy steel sleeve in reverse position; (3) there is no danger of over-torqueing . . . when threads on body of fitting are covered, a pressure-tight seal has been made, a visual assurance of a correct joint; (4) under tests, Hi-Seal fittings have withstood pressure of 4,000 psi at conditions of −320° F. to over 700° F.



with *no* leakage; (5) Hi-Seal fittings can be disconnected and reconnected as often as desired.

Complete line — Hi-Seal fittings are available in brass, steel, stainless steel. Also furnished in Titanium, Tantalum and other metals. Steel fitting supplied with cadmium plate or black phosphate finish. Conform to J.I.C., A.S.M.E. and A.S.A. standards. In sizes for ⅛" to 1½" O.D. tubing. Furnished with Long Dryseal pipe threads or straight thread port seal.

Write for Bulletin No. 3061

New high-pressure valves assemble directly to tubing — eliminate additional fittings

A revolutionary new line of Imperial needle valves designed for working pressures up to 5,000 psi., and temperatures to 450° F., employs Hi-Seal tubing connections.

Write for Bulletin 3096, or Catalog No. 200

CONTACT YOUR INDUSTRIAL DISTRIBUTOR OR WRITE TO:

THE IMPERIAL BRASS MFG. CO.
Dept. ICS-79, 6300 W. Howard St.,
Chicago 48, Ill.
Please rush me Bulletins
☐ No. 3061 ☐ No. 3096 ☐ Cat. No. 200

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Company .....
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City ..... Zone ..... State .....

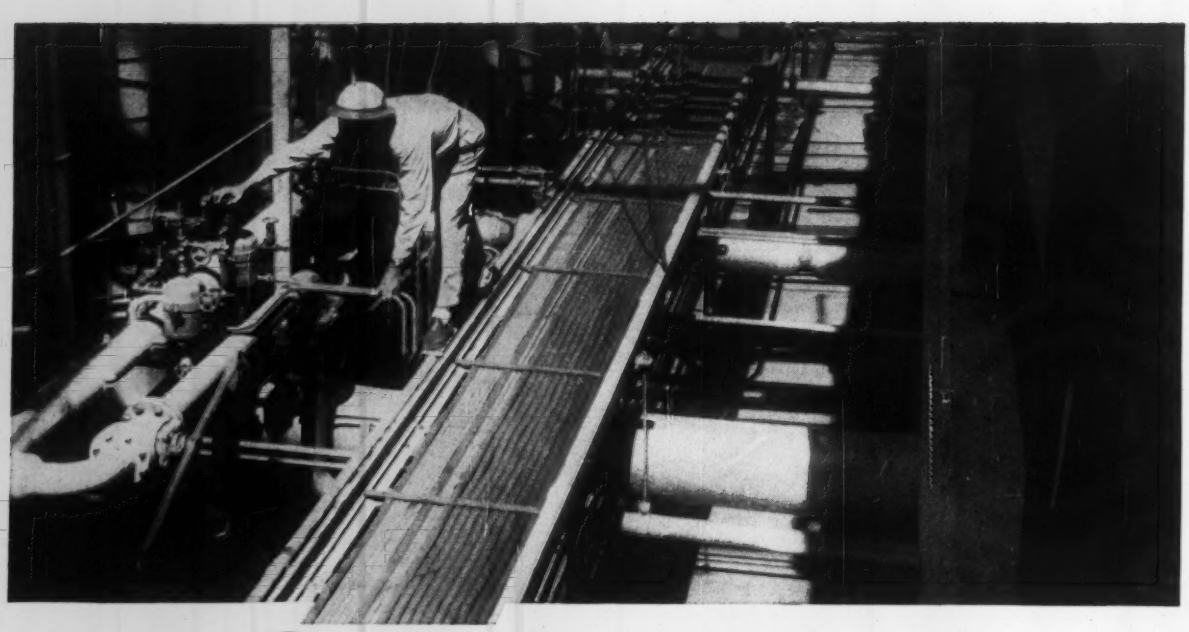
IMPERIAL

THE IMPERIAL BRASS MFG. CO.
6300 W. Howard St., Chicago 48, Ill.

In Canada: 18 Hook Ave., Toronto, Ont.

VISIT US IN BOOTH #301, ISA SHOW, CHICAGO, SEPT 21-25

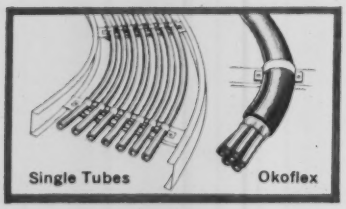
CIRCLE 41 ON READER-SERVICE CARD



New 3-WAY approach reduces cost of instrument tubing

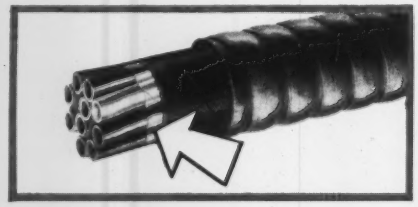
New Okoflex* armored instrument tubing costs less to install than single tubes, yet gives vastly increased resistance to corrosion and mechanical abuse. In addition, **Okoflex costs no more than ordinary multiple instrument tubing.**

Here is the Okoflex three-way approach to reducing your instrument tubing costs:



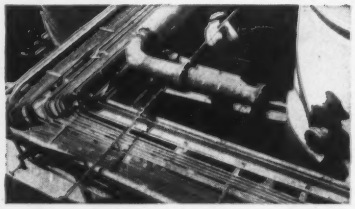
1. Lower installation cost

An Okoflex assembly, consisting of several tubes, takes about the same time to install as a single tube. Existing structures can be used for support, and standard fittings are used for attachment. Armored Okoflex can be "fished" quickly through inaccessible or hazardous locations without fear of tube damage. In addition, Okoflex can be taken down and used over and over again. It is completely salvageable.



2. More durability

Only Okoflex has a Mylar® tape over its core of tubes. This DuPont polyester film provides *extra* protection against both environmental corrosion and galvanic action between the tubes and a metallic covering. One of several Okoflex coverings—each designed for a specific situation—protects the tubes from both physical damage and corrosion. All tubes are tested at not less than 150 psi prior to cabling, and every foot of an Okoflex corrosion-resistant sheath is electrically tested at 4,000 volts to insure that no perforations are present.



3. Tube flattening eliminated

Okoflex cabled tubes—spiraled like strands of rope—can be bent on a small radius without distortion or flattening. Circular in shape, Okoflex' smooth exterior permits easy water and vapor-tight connections with standard fittings. Stresses are distributed evenly to give excellent resistance to mechanical abuse. And on delivery, you'll find that *every* tube is usable . . . none bent or damaged.

* Okoflex is licensed under U.S. Patent No. 2,578,280

THE OKONITE COMPANY
Subsidiary of Kennecott Copper Corporation
Passaic, New Jersey

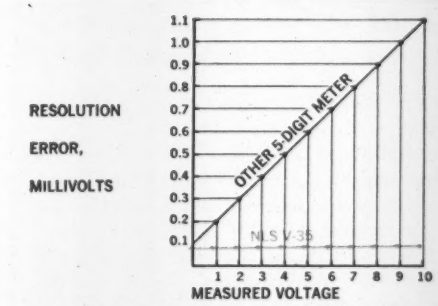
OKOFLEX . . . the low cost way to install instrument tubing

8902A

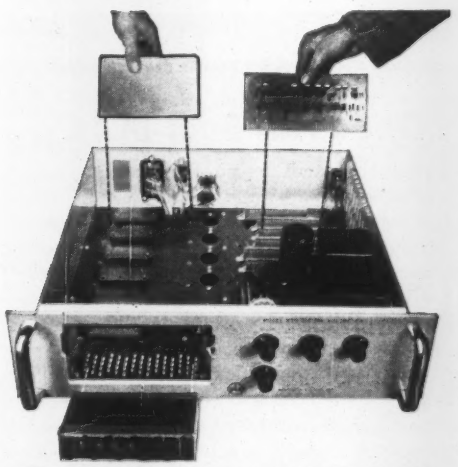
CIRCLE 42 ON READER-SERVICE CARD

FIRST DIGITAL VOLTMETER WITH THE FACTUAL FIFTH FIGURE

+9 6 .4 3 8



This chart shows the significant resolution error that results in other five-digit meters as compared to the NLS V-35 with the *factual fifth figure.*



Compact, plug-in design of the NLS V-35

The All-Transistorized NLS V-35

Here for the first time is a *true* five-digit voltmeter with a factual fifth figure. Increased accuracy of *full* five-digit resolution — 0.001% — results from the new mathematically perfect logic of the NLS V-35.

Other five-digit digital voltmeters require "desensitizing" to prevent oscillation of the least significant digit. This results in a resolution error of three to nine digits in the upper portions of each range as graphically displayed in the chart to the left. This comparison clearly shows the increased accuracy of the NLS V-35, made possible by full five-digit resolution.

In new logic . . . in all-transistorized circuitry, including logic . . . in new simplified design with *plug-in* circuit boards, *plug-in* oil-bathed stepping switches, and *snap-in* readout . . . the NLS V-35 leads its field. Write today for complete information.

NLS V-35 Specifications

Measures Voltage from ±0.0001 to ±999.99, Ratio from ±.00001 to ±.99999 . . . 10 Megohm Input Impedance . . . 0.01% Accuracy . . . Automatic Selection of Range and Polarity . . . And Measures Three Times Faster Than Any Other Stepping Switch Instrument.

Originators of the Digital Voltmeter

non-linear systems, inc.

DEL MAR (San Diego), California

NLS — The Digital Voltmeter That Works . . . And Works . . . And Works!

WESCON Booth No. 1416

CIRCLE 43 ON READER-SERVICE CARD

ANNOUNCING

Model 520 . . . manual range switching AC, DC, OHMS . . . $1190. Rack or portable.
Model 500 . . . automatic range switching DC only . . . $1190. Rack or portable.

The First New Development in Digital Voltmeters

- Absolute dc accuracy . . . 0.1% full scale.
- *Input impedance (dc) . . . approaching infinity except on 1200 V dc which is 20 megohms.
- Requires no lead switching . . . polarity indication is automatic.
- Requires no range switching on Model 500 . . . range is switched automatically.
- High stability, all-electronic four-digit indication appears in less than 125 milliseconds after step function voltage is applied across test leads.
- 0.001 to 1200 V dc range. Model 520 also reads 0.001 to 1200 V ac and 1 ohm to 1 meg.
- Output provisions for direct drive of printer or tape punch.
- Rack mounting or portable.
- Guaranteed long term stability at least 24 hrs. after 10-minute warmup and internal calibration.

* May be quickly zeroed for effectively infinite input impedance.

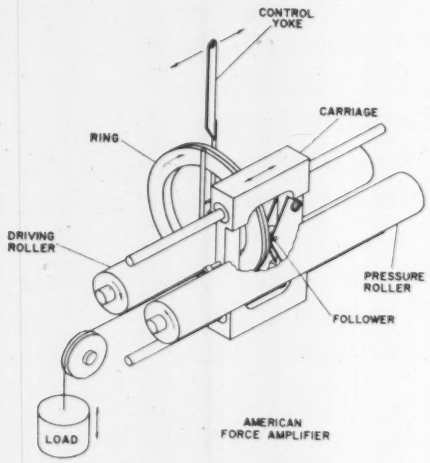
FRANKLIN electronics, inc.
BRIDGEPORT • PENNA.

CIRCLE 36 ON READER-SERVICE CARD

BRIEFS—CONTINUED

Force Amplifier Accepts Diverse Variables

The American Force Amplifier is an ultra sensitive . . . mechanical servo for the amplification of minute forces. It can be actuated directly by mechanical flow, pressure, or temperature measuring elements or similar motion producing devices. Less than one gram (0.04 oz) force is required to accurately position the amplifier . . .



The Force Amplifier consists of two parallel rollers with a ring encircling one roller, a yoke to control the ring's position, and a follower which contacts the ring between the rollers. Friction contact . . . transmits motion from the driving roller to the ring and from the ring to the pressure roller. Power for the driving roller is supplied by any external source such as a subfractional horsepower electric motor . . . The output motion is linear and reproduces the input motion within 0.001 inches with a constant load . . . (*From new 4-page Data Sheet* 301-1, *American Meter Co., Mechanical Components Dept., P. O. Box* 309, *Garland, Texas.*)

FOR THIS LITERATURE CIRCLE 194 ON READER SERVICE CARD

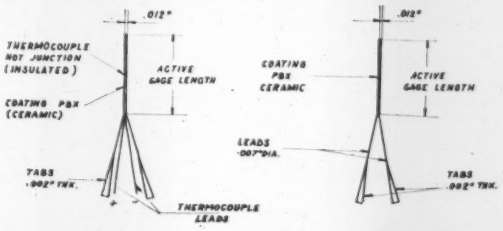
Strain Gage Has Built-in TC

The HTM Mono-Filament Strain Gage and Strain Insert represent a new type of Strain Transducer. The unique construction opens new areas to strain measurement, both at room temperature and at elevated temperature, and permits a great simplification in the installation of High Temperature Strain Gages.

The HTM Mono-Filament Strain Gage is manufactured in four standard configurations, and in four standard series . . . The unique design of this sensing element eliminates transverse sensitivity.

Configuration B is an adaptation of Configuration A into which a thermocouple has been incorporated. This thermocouple is completely insulated and is extremely small so that it can sense very rapid changes

in the temperature at the center of the strain element. In Configurations C and D an aluminum oxide insulating guide is used to support a portion of the lead wires. This guide makes the whole unit more rigid and facilitates the use of the gage as an insert. As in the other configurations, the active filament is coated



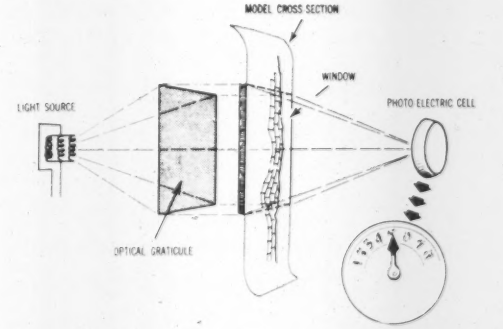
with electrically insulating cement and cured. Configuration D is manufactured with a highly responsive thermocouple to sense rapid changes in the temperature at the center of the strain element . . . (*From new 12-page Bulletin "The HTM Mono-Filament Strain Gage and Strain Insert", High Temperature Instruments Corp., Bala-Cynwyd, Penna.*)

FOR THIS LITERATURE CIRCLE 195 ON READER SERVICE CARD

Optical Analog Computer

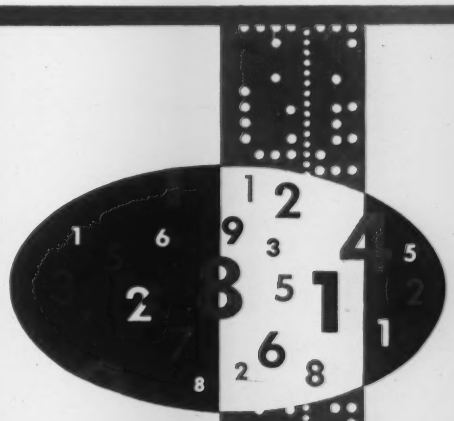
The SSC Optical Analog Computer is an instrument designed to solve potential field equations through the use of models. It is particularly useful in handling gravity and magnetic problems . . .

The theory of the computer is based on the use of graticule charts to compute the gravitational response of a model. By the conversion of a gravity graticule to an optical graticule, the distribution of light inten-



sity through the window of the computer corresponds to that of the vertical component of the gravitational force field for a unit density mass. Superimposed on this light field is a semi-transparent geologic cross-section. The opacity of the cross-section is used to represent the density of the model. The optical graticule and the geological cross-section combine to control the total amount of light falling on a photo electric cell. The amount of light transmitted to the photo electric cell is proportional to the vertical component of the gravitational force field at the point of measurement. The electrical output of the photo electric cell is expressed in milligals. By using successive measuring points a gravitational profile is obtained . . . (*From new 2-page bulletin, Seismograph Service Corp., P. O. Box 1590, Tulsa, Okla.*)

FOR THIS LITERATURE CIRCLE 196 ON READER SERVICE CARD



engineering the unusual in digital instrumentation

Peak engineering loads, tight delivery schedules, shortages of personnel . . . all place an added strain on overtaxed engineering facilities. If digital equipment engineering is part of this load, Franklin Electronics' Communications and Control Division can serve you best. Franklin's C & C Division, working in close cooperation with your engineering staff, designs and develops digital instruments and data systems to your specifications.

Whether the need is for a complete data acquisition and reduction system, a language translator, or a simple digitizer, you'll be pleased with how the C & C Division can ease your engineering load. But most of all, you'll be pleased with the final product . . . delivered on time . . . on a guaranteed performance basis.

Bulletin CC-220 describes the work of the C & C Division, its facilities, some of the equipment it has developed in the past . . . and how it can assist you now. Write for a copy. There's no obligation, of course.

FRANKLIN electronics, inc

COMMUNICATIONS AND CONTROL DIVISION
VAN NUYS, CALIFORNIA

CIRCLE 37 ON READER-SERVICE CARD

Con-O-Pak thermocouples break the 4000°F barrier

It is now possible to measure temperatures accurately in vacuums or inert atmospheres to 4000°F and above with a single homogeneous assembly. Due to their homogeneous structure Con-O-Pak thermocouples can be formed around an exceedingly small diameter without loss of insulation resistance or dielectric strength. By combining a tantalum sheath, beryllium oxide insulation and tungsten/rhenium conductors, Continental Sensing has achieved a thermocouple accurate to 4000°F. Tungsten/rhenium thermocouples produce a relatively high EMF and are extremely sensitive to temperature change.

"Rhenium-tungsten thermocouples have been calibrated to 4000°F with an accuracy of 0.1 mv." *

For accurate temperature measurement to 3000°F in oxidizing atmospheres, Con-O-Pak provides thermocouples with platinum/platinum rhodium conductors and beryllium oxide insulation in a platinum/rhodium sheath. Calibration curves are available for all noble metal thermocouple combinations.

Con-O-Pak thermocouples cover the complete temperature range from −268°F to +4000°F. They are available in diameters from .025" to .312" and with a wide variety of junctions and terminations.

Discuss your applications with us in Booth 765 at the Instruments and Automation Conference in Chicago September 21 to 25.

*From "Calibration of Thermocouples to 4000°F" by J. C. Lachman—Instruments and Control Systems, July, 1959.

NEW! Con-O-Pak Stripper Kit for rapid hand baring of metallic sheathed thermocouple wire from .025" to .250" O.D. Complete with 6 heads and 5 extra precision ground tool-bits.

Write for full information..."The Con-O-Pak Story" gives construction details and quality. Data sheets give specs and application data.

CON-O-PAK®
CONTINENTAL SENSING, INC.
1950 North Ruby Street, Melrose Park, Illinois

FLEXIBLE AND SHEATHED THERMOCOUPLES • THERMOCOUPLE WIRE • HEATING ELEMENTS • CONNECTORS

CIRCLE 45 ON READER-SERVICE CARD

book reviews

Automation, Cybernetics and Society, by F. H. George 1959, Philosophical Library, Inc., 15 East 40th St., New York 16, N. Y. 283 p., 8¾", cloth-bound $6.00. Reflects British opinions, but also general aspects, and elucidates mainly feedback-automation.

Proceedings of the National Conference on Industrial Hydraulics, Vol. XII, 14th Annual Meeting 1958, [c1958] National Conference on Industrial Hydraulics, Illinois Institute of Technology, Technology Center, Chicago 16, Ill. Contains 27 papers given at 1958-Conference.

The Properties, Physics, and Designs of Semiconductor Devices, by John N. Shive, [c1959] D. Van Nostrand Company, Inc., Princeton, N. J., 487 p., 9¼"., cloth-bound $9.75. Book covers the thermistor, the varistor, the photoelectric cell, and the transistor. Intimately allies solid-state theory with practice.

Industrial Noise Manual, [c1958] by American Industrial Hygiene Association, 14125 Prevost, Detroit 27, Mich., 180 p., 8½" x 11", paper-bound $7.50. Compilation of factual data by members of Noise Committee presented in 11 chapters from physics of sound to engineering control of noise.

Electronic Designers' Handbook, by Robert W. Landee, Donavan E. Davis, and Albert P. Albrecht, [c1957] McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y., 1029 p., 9¼", cloth-bound, $16.50 Covers entire electronic field in 23 sections reaching into analysis of feedback systems, design of stabilized d-c amplifiers, etc., with examples, graphical and tabular data.

Praktische Beispiele zur Automatisierung (Practical Examples of Automation), edited by Rationalisierungs-Kuratorium der Deutschen Wirtschaft, [c1959] Carl Hanser Verlag, Kolbergerstr. 22, Munich 27, West Germany, 202 p., 9½", cloth-bound DM24.00. Book selects three installations in West Germany, five examples from England, and one application of automation each from France and Italy from papers which were presented at the 1957 Conference on Automation in Paris, France.

Automatisierung (Automation), edited by Rationalisierungs-Kuratorium der Deutschen Wirtschaft, [c1957] Carl Hanser Verlag, Kolbergstr. 22, Munich 27, West Germany, 259 p., 9½", cloth-bound DM22.00. The subtitle calls it a report on the state of the art of automation and its effect in West Germany. 200 companies, either makers of automation equipment or describing applications in their own plant, have cooperated.

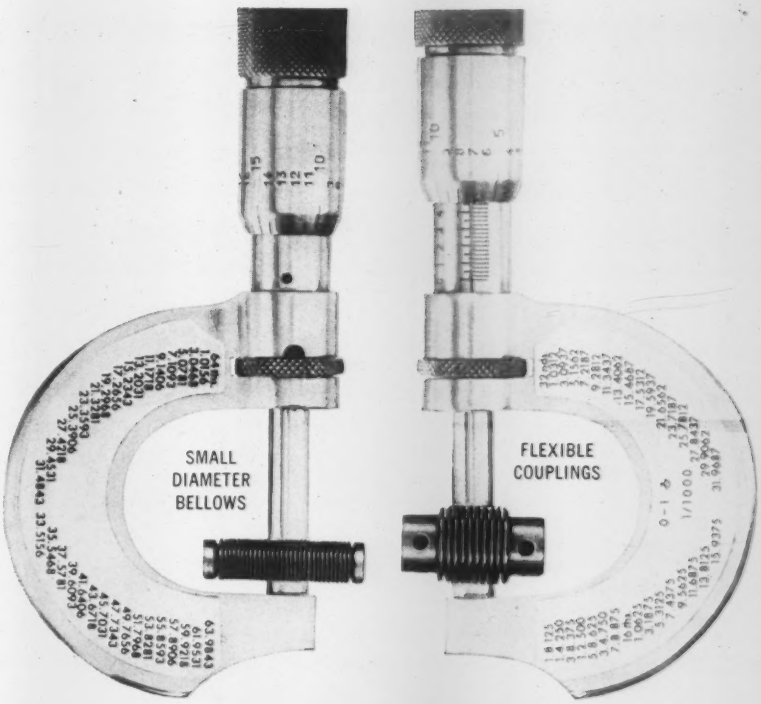
Automatologie (Automatology), by Wolfgang Schmid, [c1952] Carl Hanser Verlag, Kolbergstr. 22, Munich 27, West Germany, 284 p., 8½", cloth-bound DM23.00. The title, introducing a new term not used to this day in the U.S., implies "the science of automating." The book deals solely with Detroit type of automation and subdivides mechanisms for automatic machine tools into six different classes which are described in as many chapters.

Mathematical Programming and Electrical Networks, by Jack Bonnell Dennis, [c1959] by The Massachusetts Institute of Technology, Technology Press of MIT and John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 186 p., 9¼", $4.50, cloth-bound. This third book in the Research Monographs series offers a new approach to mathematical programming based on an analogy with electrical networks.

Flashtube Data Manual, by General Electric Company, Photo Lamp Department, Nela Park, Cleveland 12, Ohio, 70 p., 8¼" paper-bound $.50. Contains data on all GE flashtubes, including performance charts, maximum ratings, and typical circuit diagrams.

Microminiaturization of Electronic Assemblies, edited by Eleanor F. Horsey and Laurence D. Shergalis, Hayden Book Co., Inc., 830 Third Ave., New York 22, New York, 288p, 9¼", cloth-bound, $11.00. Most of the material was presented at the "Symposium on Microminiaturization of Electronic Assemblies" sponsored by the Diamond Ordnance Fuze Laboratories in 1958. Details latest techniques in "two-dimensional" packaging and similar developments.

The Philosophy of Space and Time by Hans Reichenbach, translated from German by Maria Reichenbach [c1958] Dover Publications, Inc., 180 Varick St., New York 14, N. Y., 295 p., 8", paper-bound $2.00. Book covers theory of true time and consequence of Einstein's relativity, theory, using intermediate mathematics.



MINIATURIZE WITH Robertshaw

Looking for new ways to save space and weight in instruments, aircraft, missiles and other equipment? Investigate these two miniature products by Robertshaw:

Small Diameter Metallic Bellows, only ¼" and 5/16" O.D., provide exceptional strength, precision and sensitivity to temperature and pressure changes. Hydraulically formed without seams to your strictest specifications in a wide range of bellows metals, physical properties and performance characteristics. Available in unlimited quantities.

WRITE FOR BULLETIN F-108.

Small Diameter Flexible Couplings, available from stock, in several metals and sizes as small as 15/32" O.D. . . . smaller diameters custom-engineered on request. Eliminate back-lash, maintain uniform angular velocity, reduce bearing wear and friction in a variety of applications. Stock couplings accommodate shaft sizes ⅛" to ½" diameter.

WRITE FOR DATA SHEET F-808.

Mr Controls

Robertshaw-Fulton CONTROLS COMPANY

BRIDGEPORT THERMOSTAT DIVISION • Milford, Conn.

CIRCLE 46 ON READER-SERVICE CARD

Bristol Series 500 Air Controllers (top three rows) measure and control asphalt in Wood Conversion Company's new plant. Series 93 instruments (lower two rows) measure temperatures of saturating and coating asphalt and starch coating in edge sealer operation.

69 Bristol Instruments....

BRISTOL... for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

COME IN AND SEE US AT BOOTHS 420-428 AT THE ISA SHOW

All the recording and automatic controlling instruments in this new 220,000 square-foot plant of the Wood Conversion Company, Riverside, New Jersey, were supplied by Bristol

Bristol engineers worked closely with Wood Conversion engineers in instrumenting the plant's huge blanket machine that turns out Balsam Wool®, used for housing insulation, and Tufflex®, used for cushion padding, sound deadening, and protective packaging. A wide variety of forms of these basic blanket products is turned out.

Bristol instruments ". . . . take the human-error-factor out of the all-important quality-control of our manufacturing process," says E. O. Lieberg, the plant's Technical Supervisor.

The Wood Conversion Company installation is just one example of modern Bristol instrumentation for the pulp and paper industry. In your own company, Bristol engineers are always ready to work closely with your engineers, in the design stages, in setting up instrumentation for new plants. And they are available to assist you in modernizing and improving instrumentation in your existing plants.

Temperature, pressure, absolute pressure or vacuum, flow, liquid level, humidity, pH, tension, thickness, speed and mechanical motion are just a few of the variables that can be recorded or exactly controlled at any point or points in your process. And Bristol gives you a tremendous selection of instruments to do the job, including Electronic Dynamaster* potentiometers and pyrometers, pneumatic and time-program controllers.

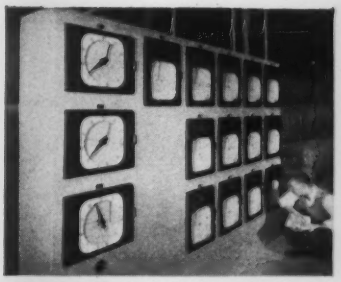
..guard important operations in new Wood Conversion plant

. . . one of many Bristol installations in the pulp and paper industries

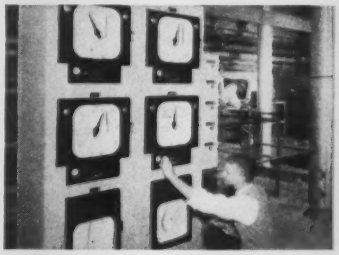
Bristol makes the most complete line on the market of full-size and miniature instruments—electronic and pneumatic types—for measurement, recording, automatic control and telemetering of almost every industrial variable. Bristol Application Engineers are always ready to advise and assist you in applying them to your process. Write: The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.

**T.M. Reg. U.S. Pat. Off.*

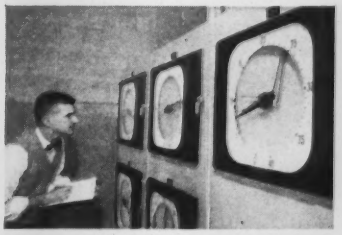
9.13



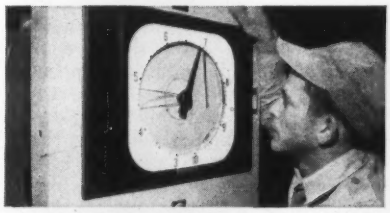
Dryer wire tension and dryer oven temperature are controlled from this panel of Bristol 500 and Dynamaster* instruments. Dryer wire is accurately tensioned, despite thermal expansion and contraction, by Bristol control.



Temperature and fire control of preliminary dryer are controlled at this panel. Bristol Dynamaster* Air Controllers, with external control station (top two rows), and Bristol Series 500 Recorders are the instruments.

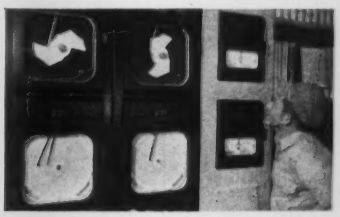


These Electronic Dynamaster Recorders provide continuous indication and permanent record of asphalt and fuel oil temperature. Dynamasters are also available for electrical measurement and either electric or pneumatic control.



Binder pH is recorded by this Bristol Dynamaster. Government specs allow pH between 6 and 8, with 7 the norm. But Wood Conversion says, with Bristol recording of pH, the control to comply with specification is easier and more certain.

E. O. Lieberg, Technical Supervisor at Wood Conversion Company's Riverside, N. J., plant, checks performance of Bristol indicator-controller for main steam to ply machine and edge sealers. Bristol offers a wide variety of indicator-controllers.



Time-temperature program for binder cooking cycle is controlled by four Bristol instruments at left on this panel. Accurate temperature cycling is a necessity to produce proper binder.

CIRCLE 47 ON READER-SERVICE CARD

MEN

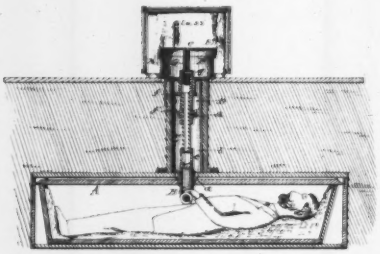
Basically, the rapid advances made by Bryant in the field of magnetic storage drums are due to the technical capability and long experience of Bryant's research, engineering and production men. Full details are in our new descriptive brochure. Write for your copy. Bryant Computer Products Division, a division of Bryant Chucking Grinder Company, P. O. Box 620, Springfield, Vermont.

CIRCLE 48 ON READER-SERVICE CARD

panhandle pete

ERROR INDICATOR

My invention has relation to that class of devices for indicating life in persons buried under doubt of being in a trance in which connection is obtained between the person in the grave and an indicator on the ground over the grave through a casing or tube leading from the surface of the ground down to the coffin; and it consists in the improved construction, combination, and arrangement of parts of the same, as hereinafter more fully described and claimed.



In the accompanying drawings, the letter A represents a coffin or burial-casket, of any desired shape, with a body in it. In the lid of the coffin is a bushing, a, through which passes a T-shaped pipe, B, having a cross-pin, b, in the upper end, and the branches of which rest on the body near its hands. The cross-pin b passes into a longitudinal slot, c, of a pipe, C, which fits into the upper end of the pipe B. By means of a set-screw, d, a sleeve, D, is adjustably fastened to the upper end of the tube C. This sleeve is provided with a catch, f', which clasps the flanged collar f of the neck of a cylindrical box, F, fastened above the grave, and provided with a flanged cover, E, which freely turns on the upper edge of the box F. In the center of cover E is a circular aperture, e, to which is fitted a tube, G, whose lower slotted end engages a cross-pin, g, in the upper end of sleeve D. To the flange of cover E is fastened an index, h, which points to a marked scale, H, on the side of box F, which is fastened on a wooden box extending from the coffin to the surface of the grave.

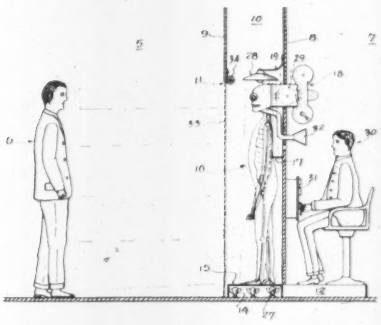
It will be seen that if the person buried should come to life a motion of his hands will turn the branches of the T-shaped pipe B, upon or near

which his hands are placed, and by each of the different pipes being connected by having the cross-pin in its upper end engaging the slot in the lower end of the one above, the cover E will turn and the index will show on the scale that it has been turned. If the person then should turn in the coffin or make any more violent motion, he will push the pipe B upward and push the cover off the top of the box. The catch f′ on the sleeve D will be pushed over the flanged collar f and hold it up, so that nobody from the outside can press the cover down again.

John G. Krichbaum
Patent 268,693
Patented Dec. 5, 1882

APPARATUS FOR OBTAINING CRIMINAL CONFESSIONS AND PHOTOGRAPHICALLY RECORDING THEM

The present invention relates to a new and useful apparatus for obtaining confessions from culprits, or those suspected of the commission of crimes, and photographically recording these confessions, in the form of sound waves, in conjunction with their pictures, depicting their every expression and emotion, to be preserved for later reproduction as evidence against them.



The primary object of my invention is the provision of an apparatus for the creation of illusory effects calculated to impress the subject with their being of a supernatural character and to so work upon his imagination as to enable an inquisitor operating in conjunction with the recording system to obtain confessions and graphically record them by light action under the control of electric impulses governed by varying intensities of sound waves.

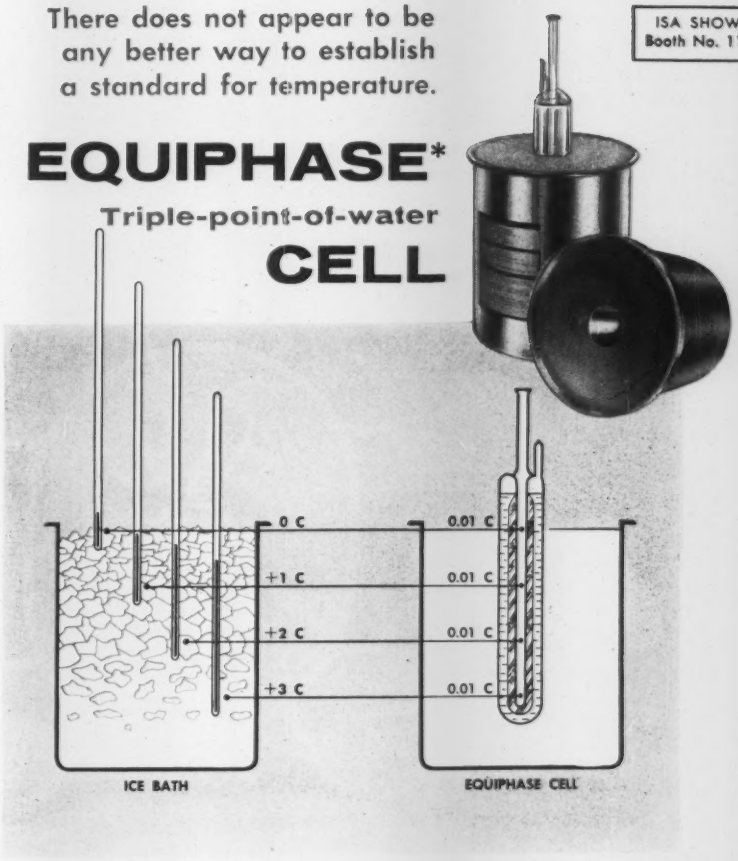
Helene Adelaide Shelby
Patent 1,749,090
Patented Mar. 4, 1950

There does not appear to be any better way to establish a standard for temperature.

ISA SHOW
Booth No. 117

EQUIPHASE*

Triple-point-of-water CELL



The triple-point-of-water is a physical constant which defines the Thermodynamic Temperature at 0.0100 C when water exists in equilibrium with its ice and vapor at a pressure of 4.58 mm Hg. "By taking a physical constant to define our temperature scale, we have gained a great deal and lost nothing in precision of temperature measurement. There does not appear to be any better way to establish a standard for temperature."†

The Equiphase Cell is an instrument for realizing the stable temperature established by the triple-point-of-water, with a guaranteed accuracy of better than 5×10^{-4}C.

The conventional ice bath is impractical for use as a true temperature reference because it is liable to errors of varying magnitudes including: failure to achieve equilibrium between ice and water (error to 3.98 C); dissolved impurities, salt (error to 2 C) failure to air-saturate the water (error to 0.0024 C); atmospheric pressure (error to 0.0017 C).

With the Equiphase Cell, on the other hand, the triple-point-of-water is established, which is by definition a fundamental fixed point at exactly 0.0100 C on the Thermodynamic Temperature Scale.

Equiphase Cells are now available in a convenient, easy-to-use package, complete with instruction booklet. These instruments are 17″ high and 8″ in diameter. Write for Equiphase Cell Technical Bulletin to Trans-Sonics, Inc., Dept. 19, Burlington, Mass.

†A. G. McNish: "The Basis of our Measuring System", Proceedings of the I.R.E., May, 1959
*Trademark

TRANS-SONICS T.M.

Precision Transducers

CIRCLE 49 ON READER-SERVICE CARD

Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

LOW LEVEL INPUT AMPLIFICATION

- *1,000,000:1 rejection ratio at 60 cps*
- *floating input*
- *isolated output*

IN 2 NEW SANBORN CHOPPER AMPLIFIERS

INDIVIDUAL SET-UPS

portable, self-contained unit amplifier

The Model 350-1500 Low Level Amplifier provides extremely versatile measurement of low level signals through use of two interchangeable plug-in circuits — one for thermocouple applications, another for DC strain gage work (other plug-ins now in development). Floating input and isolated output make the 350-1500 useful when signal measurements are made in the presence of large ground loop voltages. The 10-1/2″ high x 4-3/16″ wide 350-1500 may be used individually with its own power supply to drive a 'scope, meter, optical element, etc. or as a preamplifier in 6- or 8-channel 350 series recording systems.

MULTI-CHANNEL INSTALLATIONS

8-unit 7″ high modules for "850" series direct writers

Compact Model 850-1500A Low Level Preamplifiers are economical, space-saving units for large installations such as aircraft and missile development and test facilities where many recording channels are used to monitor strain gage and thermocouple outputs. Required 440 cps chopper drive voltages can be supplied for up to 16 channels with the *Model 850-1900 MOPA*.

SPECIFICATIONS

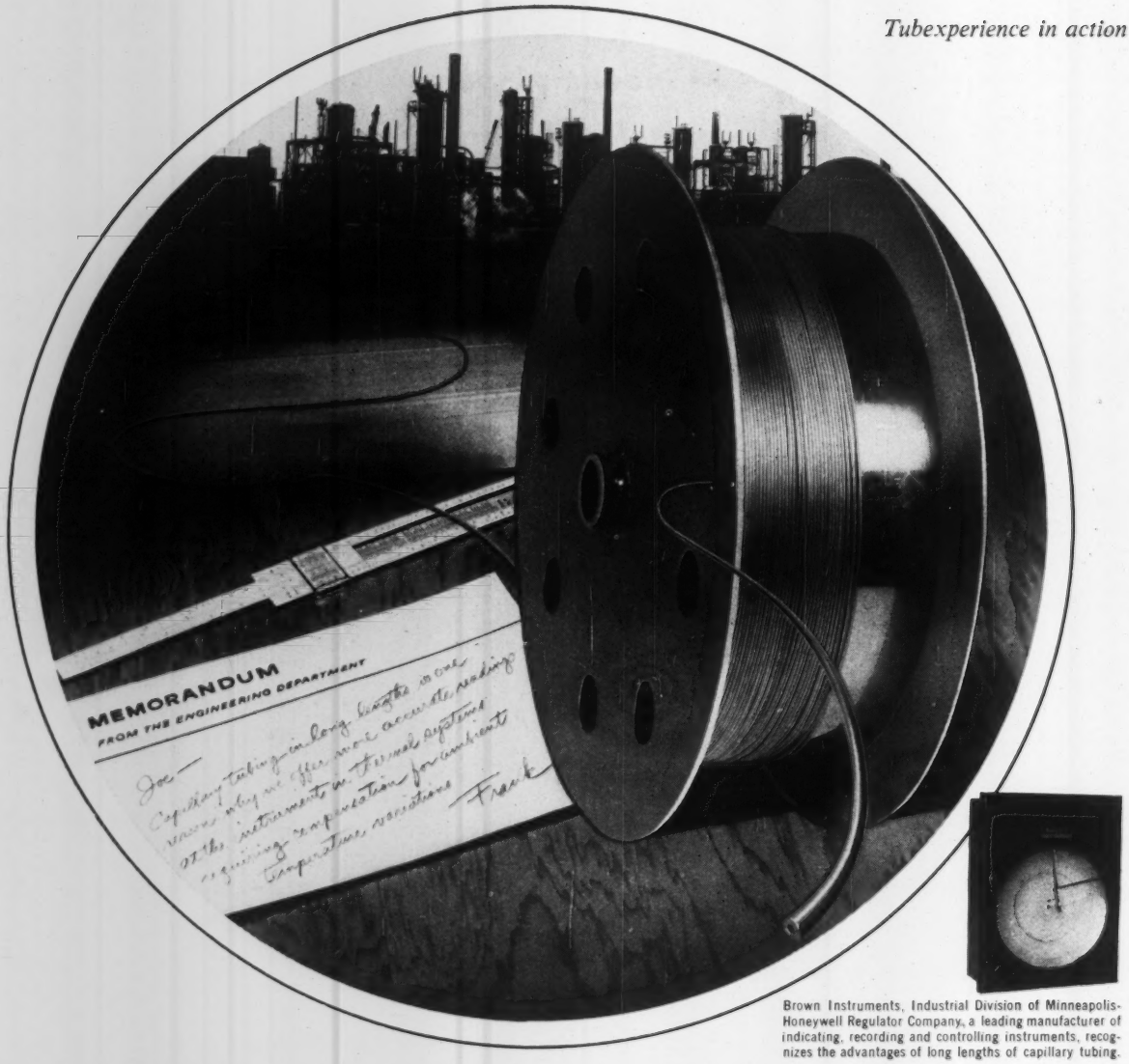
	350-1500	850-1500A
Sensitivity	20 uv input for 1 volt output, or 10 chart div. with Sanborn recorder; X1 to X2000 attenuator	100 uv input for 1 volt output, or 10 chart div. with Sanborn recorder; X1 to X200 attenuator
Input	Floating, can be grounded	
Input Impedance	100,000 ohms	200,000 ohms
Output	Floating or grounded (independent of input)	
Output Impedance	350 ohms	
Output Capabilities	±2.5 volts across 1000 ohm load	
Bandwidth	DC – 100 cps (3db)	
Linearity	±0.1% of full scale	
Common Mode Performance	120 db for 60 cps and 160 db for DC with 5000 ohms unbalance in source	
Noise	2 uv peak-to-peak over a 0 to 100 cps bandwidth	
Drift	±2 uv for 24 hours	
Gain Stability	±0.1% for 24 hours	

(specifications subject to change without notice)

Complete specifications and application data are available from Sanborn Sales-Engineering Representatives in principal cities throughout the United States, Canada, and foreign countries.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman Street, Waltham 54, Mass.

CIRCLE 50 ON READER-SERVICE CARD



Brown Instruments, Industrial Division of Minneapolis-Honeywell Regulator Company, a leading manufacturer of indicating, recording and controlling instruments, recognizes the advantages of long lengths of capillary tubing.

Up to 3000 ft. of capillary tubing in 1 piece

Seldom does an instrument installation require 3000 ft. of capillary tubing in one piece—the quantity is normally much less. But the advantages of long lengths are numerous. A simple long length of capillary tubing has greater ID uniformity than a series of short lengths separately produced. This permits more accurate transmission of data between instruments controlling a process. Instrument manufacturers find that long lengths reduce scrap. They also lessen the number of setups required and the costs of inserting the capillary tubing in flexible metallic protective sheathing.

Superior has spent years in the development of manufacturing processes and quality control procedures for the production of close tolerance tubing. ODs range up to $\frac{3}{16}$ in., IDs from .004 through .040 in. Analyses include Types 304, 316, 321, 347 and 446 stainless; also Monel, Inconel, nickel and carbon steel alloys. Data Memorandum No. 11 gives complete details—let us send you a copy. Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

Monel and Inconel are registered trademarks of International Nickel Co.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

CIRCLE 51 ON READER-SERVICE CARD

events

September 1-3

14th National Conference of Association for Computing Machinery, Massachusetts Institute of Technology. For information write Frank M. Verzuh, Computation Center, MIT, Cambridge 39, Mass.

September 21-22

8th Annual Meeting, Standards Engineering Society, Somerset Hotel, Boston, Mass. For more information write Charles Ajamian, P.O. Box 538, Wayland, Mass.

September 1-3

14th National ACM Conference, Massachusetts Institute of Technology, Cambridge, Mass. For information write Frank Verzuh, MIT, Cambridge, Mass.

September 21-25

Fourteenth Annual Instrument Society of America Conference and Exhibit, International Amphitheater, Chicago, Ill. For information write F. Tabery, 3443 South Hill St., Los Angeles 7, Calif.

September 22-24

Third Industrial Nuclear Technology Conference, Morrison Hotel, Chicago, Ill. For information write L. Reiffel, Armour Research Foundation, Technology Center, Chicago 16, Ill.

September 23-25

Special Technical Conference on Non-Linear Magnetics and Magnetic Amplifiers, Shoreham Hotel, Washington, D.C. For information write John Leslie Whitlock Associates, 6044 Ninth St., North, Arlington, Virginia.

September 28-October 1

Ninth Annual Instrument Symposium and Research Equipment Exhibit, National Institutes of Health, Bethesda, Md. For information write James B. Davis, National Institutes of Health, Public Health Service, Bethesda 14, Md.

October 5-7

Fifth National Communications Symposium, sponsored by IRE Professional Group on Communications Systems, Hotel Utica, Utica, N. Y. For information write C. W. Gordon, 1403 Bedford St., Rome, N. Y.

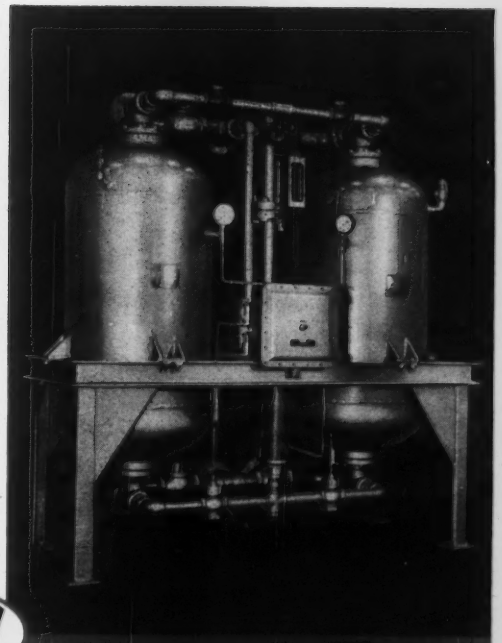
October 7-9

1959 National Symposium on Vacuum Technology, Sheraton Hotel, Philadelphia, Penna. For information write C. B. Willingham, American Vacuum Society, Box 1282, Boston, Mass.

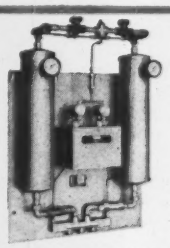
October 12-14

National Electronics Conference, cosponsored by Illinois Institute of Technology and two technical societies and two universities, Hotel Sherman, Chicago, Ill.

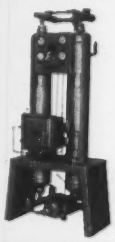
some remarkable **FACTS** about the TRINITY



Heat-Les desiccant DRYER



Heat-Les dryers are available in a wide range of capacities to meet all industrial and military needs.



1. **REJECTS OIL**—Eliminates the need for accessory oil filters and ensuing replacements of desiccant or filter cartridges.

2. **LOWER INITIAL COST**—Original equipment costs savings up to 50%, depending upon installation requirements.

3. **LOWER MAINTENANCE COSTS**—No heaters to service. Few moving parts. Designed for maximum life, minimum service requirements.

4. **COMPLETELY AUTOMATIC**—Requires no attention.

5. **DEWPOINTS AS LOW AS —180° F**—Standard guarantee—100° F at line pressure. Actual dewpoints below range of usual measurement.

Here's a working phenomenon so remarkably simple, yet so effective, you must see it to believe it. The Heat-Les Dryer is the practical answer to all industrial dynamic dehumidification needs.

WRITE FOR COMPLETE DETAILS...

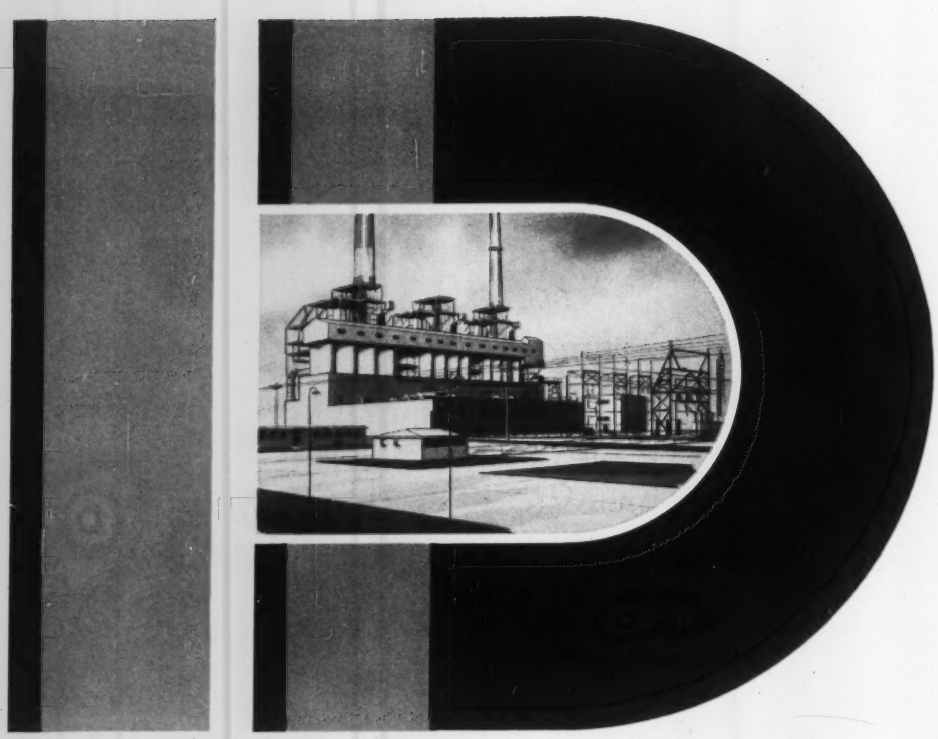
Heat-Les Dryers are available in a wide range of sizes to meet practically all requirements, and are designed to operate at 30 to 6000 psig.

TRINITY

Heat and Heat-Les reactivated dryers.
Complete air supply and purging systems.

TRINITY EQUIPMENT CORPORATION, CORTLAND, NEW YORK

CIRCLE 52 ON READER-SERVICE CARD



Little Gypsy - - - first computer controlled electric power plant!

The electric power industry took a giant step toward safer and more efficient plant operation with the announcement that the new 230,000 kw Little Gypsy Station of Louisiana Power & Light Company will be completely automatically controlled by a Daystrom digital computer control system.

The decision to go ahead with this project was backed by a year's operational experience with a Daystrom computer operating on-line at LP&L's Sterlington Steam Electric Station.

The original Sterlington installation, delivered over a year ago, came about through the combined engineering efforts of Louisiana Power & Light Company, Ebasco Services Inc., design and consulting engineers for LP&L, and Daystrom Systems.

The Sterlington computer system performance has demonstrated for the first time the reliability and utility essential to the stringent requirements of overall control responsibility. This field operating experience permits Daystrom to guarantee system operational availability of more than 99%. The uncompromising criterion of design which makes this performance possible dictates the complete elimination of vacuum tubes and moving parts.

The Little Gypsy computer system will perform the following functions: (1) Control sequentially the 800 or more steps necessary for plant start-up and shut-down, continuously checking the overall progress of the operation; (2) Monitor at the rate of ten times per second the hundreds of electrical signals signifying plant operating conditions and safety; (3) Instantly recognize abnormal conditions and take appropriate corrective action automatically; (4) Control combustion, feed water and steam temperature for best efficiency.

A substantial number of these systems have already been purchased for performance data reduction and automatic control. The availability of these new techniques and associated equipment warrant your careful study. For conference arrangements write or telephone Daystrom Systems, A-115, Miramar Road, La Jolla, California. GLencourt 4-0421.

INPUT CONSOLE—STERLINGTON COMPUTER.

DAYSTROM SYSTEMS
DIVISION OF DAYSTROM, INC.
Reliable computer control systems

CIRCLE 53 ON READER-SERVICE CARD

CASE HISTORIES

Comparator measures dimensions to one-millionth of an inch. One of many pieces of ultra-precision equipment in the New Departure instrument/miniature ball bearing laboratories.

In many bearings, various dimensions and surface finishes must be held to within tolerances of one millionth of an inch.

Instrument Ball Bearings Help Missiles Along A Bright Path Of Precision!

CUSTOMER PROBLEM:

Missile guidance system manufacturers require a dependable source for super precise instrument ball bearings. When used in spin axis and gimbal applications, for example, these ball bearings help restrict vitally important drift, through extremely close tolerances and high precision uniformity.

SOLUTION:

New Departure research, development and production facilities were applied to solving the vital problem. Visual evidence of New Departure's success is the bright path of precision written across the skies by Sperry, AChiever and other guidance systems used in many of the most advanced missiles and space craft. In the case of Sperry's gyrosyn guidance system, for example, New Departure instrument ball bearings are credited with a remarkable 1200% gain in gyro accuracy. Proof enough that New Departure has the know-how and facilities to solve tomorrow's instrument/miniature ball bearing design problems in missile and space exploration.

What's more, these New Departure facilities are available for *your* design development right now! Call or write Department I-8.

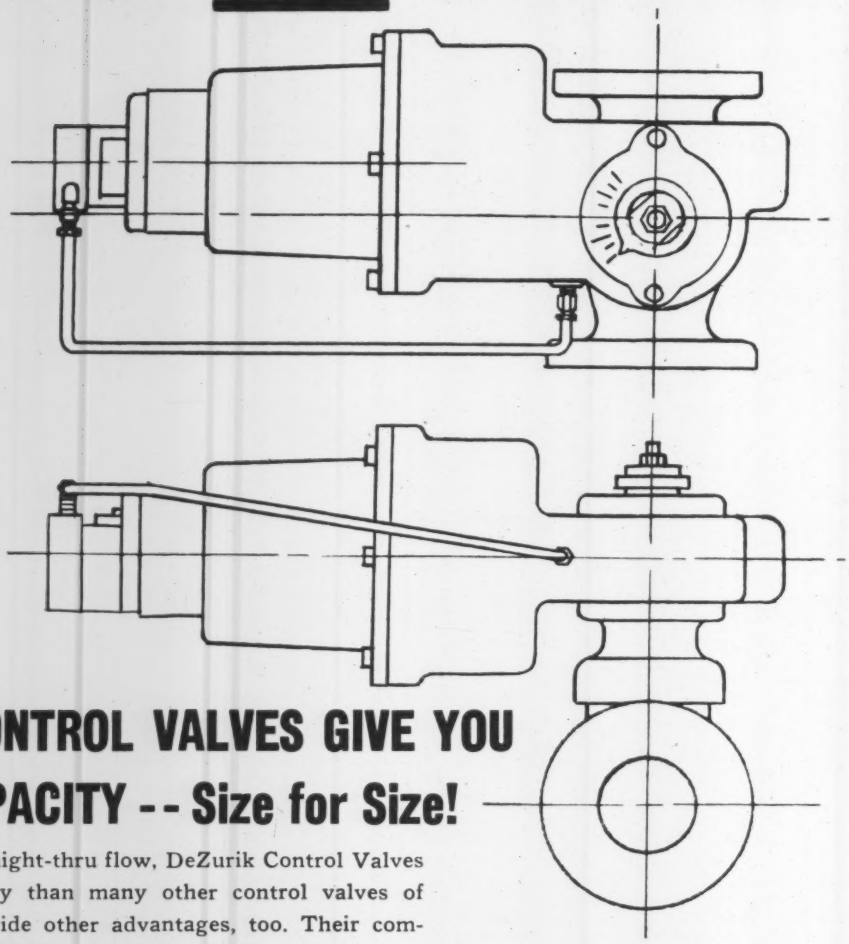
NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

CIRCLE 54 ON READER-SERVICE CARD

TRY THIS FOR SIZE!



DeZURIK CONTROL VALVES GIVE YOU HIGHER CAPACITY -- Size for Size!

Because of their straight-thru flow, DeZurik Control Valves permit higher capacity than many other control valves of equal size. They provide other advantages, too. Their compact size makes installation easy in practically any location. They deliver dead-tight shut-off despite solids in the flow. They have high rangeability, with a flow characteristic usable down to the shut-off position. They have provision for manual operation—at no extra cost. Their leak-proof stem seal eliminates a source of trouble common to many other valves. AND because of their basically simple design, DeZurik Control Valves are equipped with a positioner often at a cost less than an ordinary control valve without a positioner.

DeZurik Control Valves are available in sizes ½" thru 20" in pneumatic, hydraulic or electric models. They are produced in almost any castable metal.

INSTRUMENT ENGINEERS!

The complete story of DeZurik Control Valves is told in Bulletin 150. Get your copy from the DeZurik representative in your area, or write Dept. CV.

DeZURIK CORPORATION
SARTELL, MINNESOTA

CIRCLE 55 ON READER-SERVICE CARD

EVENTS—CONTINUED

October 13-16
Midyear Meeting of Laboratory Apparatus and Optical Sections, The Cavalier, Virginia Beach, Virginia. For information write Nick Geannopulos, SAMA, 20 N. Wacker Drive, Chicago 6, Ill.

October 13-16
Midyear Meeting of Recorder-Controller Section, Seaview Country Club, Absecon, N. J. For information write Nick Geannopulos, SAMA, 20 N. Wacker Dr., Chicago 6, Ill.

October 14
IRE Medical Electronics Professional Group Meeting on Modern Analytical Methods For Evaluating Cardio-Vascular Function, University of Penna. For information write Helen B. Yonan, Moore School, University of Penna., 33rd & Walnut Sts., Phila., Pa.

October 19-21
Joint Fall Meeting of URSI and IRE, El Cortez Hotel, Balboa Park, San Diego, California. For information write IRE, 1 E. 79th St., New York 21, N. Y.

October 25-29
Midyear Meeting of Industrial Instrument Section, Camelback Inn, Phoenix, Arizona. For information write Nick Geannopulos, SAMA, 20 N. Wacker Dr., Chicago 6, Ill.

October 28-29
6th Annual Computer Applications Symposium, Morrison Hotel, Chicago, Ill., Armour Research Foundation of the Univ. of Ill., Write M. J. Jans, Conf. Secy., Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

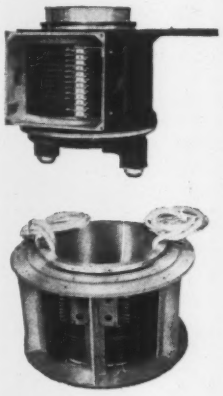
October 29-30
5th Annual Electron Devices Meeting, Shoreham Hotel, Washington, D. C., PGED-IRE, Write J. J. Lanigan, Pub. Chrman, Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N. Y.

November 3-5
1959 Mid American Electronics Conference (MAECON) Midwest Research Institute, Kansas City, Mo., Sponsored by KC Section, IRE. Write Paul C. Constant, Jr., Midwest Research Institute, 425 Volker Blvd., Kansas City 10, Mo.

November 4-6
Sectional Meeting of Society for Applied Spectroscopy & Instrument Exhibition. Hotel New Yorker, N.Y.C. For information write M. F. Wilson, Air Reduction Corp. Research Lab., Murray Hill, N. J.

November 16-19
5th Conference on Magnetism and Magnetic Materials, Sheraton-Cadillac Hotel, Detroit, Mich., Sponsored by Univ. of Mich., IRE, Am. Phys. Soc., ONR, AIEE and Met. Soc of AIME. Write D. M. Grimes, Dept. of E. E., Univ. of Mich., Ann Arbor, Mich.

BREEZE SLIP RINGS



In circuitry where slip rings must function with dependable precision and stand up under difficult operational conditions, BREEZE slip rings will do the job.

From 2-ring to 500-ring assemblies . . . currents as high as 350 amps continuous at 220 volts and 700 amps overload at 220 volts. Special high voltage designs available; radio frequency assemblies . . . high speed rotation for thermocouple and strain gage applications. Also segmented ring assemblies for accurate sequencing and timing.

Consult us or write for detailed literature.

BREEZE
CORPORATIONS, INC.
700 LIBERTY AVE., UNION, N.J.

BREEZE PRODUCTS: ACTUATORS • HOISTS • TRANSMISSIONS • GENERATORS • STARTERS
STARTER GENERATORS • BELLOWS • SLIP RINGS • HOSE CLAMPS • HITEMP FLEXIBLE TUBING

CIRCLE 56 ON READER-SERVICE CARD

TANK-O-METER
FOR MEASURING TANK CONTENTS
ANY DISTANCE AWAY

TANK MAY BE BURIED, ELEVATED, OPEN, CLOSED, VENTED OR UNDER PRESSURE OR VACUUM

SEND FOR BULLETINS

Also gauges for:
Barometric Pressure (Mercury Column)
Absolute Pressure (Mercury Column)
Pressure and Vacuum
Differential Pressure
Inclined Manometers for draft, pressure or differential pressure.

UEHLING INSTRUMENT CO. 470 GETTY AVE., PATERSON, N. J.

CIRCLE 57 ON READER-SERVICE CARD

Write your own ticket for Honeywell thermocouple wire

Choose from over 100 variations of insulated thermocouple wire and thermocouple extension wire. Honeywell can supply it from stock, with insulation in any of the conventional combinations of asbestos, glass, polyvinyl, Teflon and others. Should your application require other than conventional insulation, Honeywell can custom-make what you need, quickly and economically.

Call your local Honeywell field engineer . . . he's as near as your phone. Or write for Buyer's Guide C100-8.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Honeywell

First in Control

CIRCLE 58 ON READER-SERVICE CARD

MACKENZIE WALTON CORPORATION

50th Anniversary
1909-1959
MACKENZIE WALTON CORP.
PAWTUCKET, R. I.
Subsidiary of READING TUBE CORP.

Our Golden Anniversary Year...

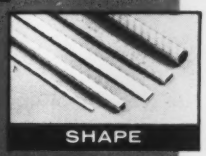
Marking a Half-Century of Precision Achievement!

CAPILLARY

THIN WALL

BOURDON

BRAIDED


SHAPE

Fifty years ago we began contributing to the development of many of the then infant instrumentation and gauge industries which have since grown in size and in importance to our country's economy and prosperity.

As specialists in the production of precision seamless tubing of copper and copper base alloys, we have grown with our customers in such fields as instrumentation, bourdon gauge, air conditioning, refrigeration, thermostatic, automotive and band instrument tubing. In those industries, quality and accuracy are indispensable and our record for delivering both has been well established over half a century of dependable service.

Our thanks go to our many accounts for their consistent patronage.

With the added research facilities available to us, as a subsidiary of Reading Tube Corporation, we now enter a second half-century of even more exciting precision achievement!

MACKENZIE WALTON CORP.
Subsidiary of READING TUBE CORPORATION • Empire State Bldg., N. Y., N. Y.
478 PAWTUCKET AVE., PAWTUCKET, R. I.
PAwtucket 2-6837

Makers of Quality Precision Small Seamless Tubing in Copper & Copper Base Alloys

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DROP IN

TO SEE US AT THE ISA SHOW, CHICAGO

BOOTH 664

We will be pleased to discuss your measurement and control problems with you.

Our publications, MILITARY SYSTEMS DESIGN, INSTRUMENTS AND CONTROL SYSTEMS and INSTRUMENT AND APPARATUS NEWS, also a full line of current technical books in the instrumentation area will be on display.

INSTRUMENTS PUBLISHING COMPANY

845 RIDGE AVE · PITTSBURGH 12, PA.

The way to know – An ominous shadow over ocean or wasteland... an unidentified "blip" on a radar scope! A challenge from an airborne AN/APX-7 interrogating unit spurts into the ether. In microseconds a reply identifies the potential marauder as friendly. The absence of such a reply alerts the protective and retaliatory might of the nation.

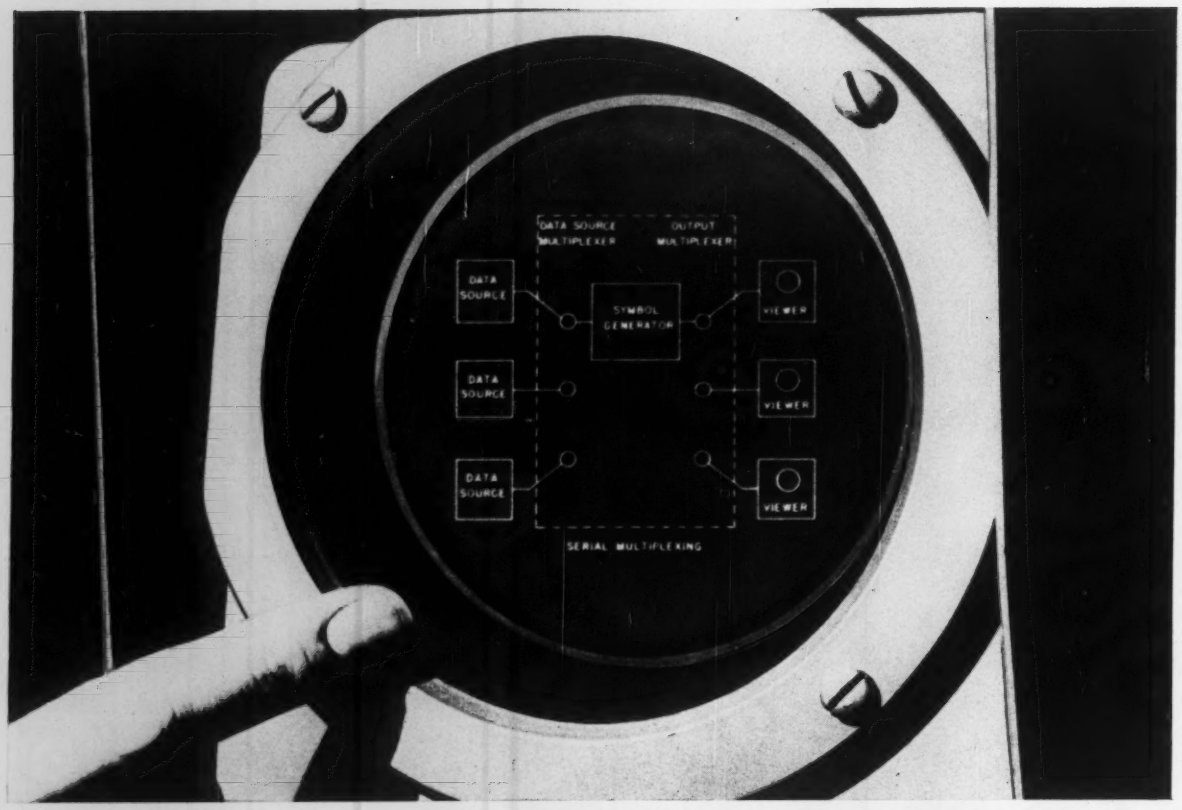
ENGINEERING BEYOND THE EXPECTED
Packard Bell's reputation as a leading designer and foremost producer of IFF (identification, friend or foe) equipment is indicated by the fact that both the AN/APX-7 and the AN/APX-6, which returns the reply, are products of our Technical Products Division. Advanced development, company-sponsored, has recently produced miniaturized IFF modules which operate up to 200°C.

PACKARD BELL ELECTRONICS
Technical Products Division
12333 W. Olympic Blvd.
Los Angeles 64, Calif. • BR. 2-4141

C '59 PB

CIRCLE 59 ON READER-SERVICE CARD

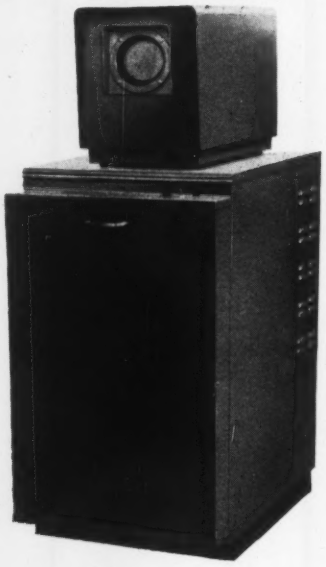
Automatic read out



NOW . . . a complete data display system at unusually low cost.

NOW . . . by using LFE's exclusive SM Symbol Generator and Viewers you can custom design a complete data display system at unusually low cost. Only *one* symbol generator is required to operate any number of viewers . . . by series or parallel multiplexing . . . each with a different display. No other display system offers this flexibility. The result is exceptionally low cost.

The SM translates coded data into the written word from any digital data source . . . computers, tape units or teletype lines. Any number of sources can supply data to the same viewer, or each viewer can be attached to one source only . . . both viewers and source can be remote. The SM quickly generates and displays alpha-numeric characters, arbitrary or abstract symbols, graphs, charts or maps. Display rate is 20,000 characters per second . . . more than 64 different characters . . . 600 characters per display . . . accepts data at non-uniform rates. Display can be held indefinitely until erased. For complete specifications write for Bulletin 81.



SYMBOL GENERATOR AND VIEWER

Computer Products Division

LABORATORY FOR ELECTRONICS, INC.
1079 COMMONWEALTH AVENUE, BOSTON

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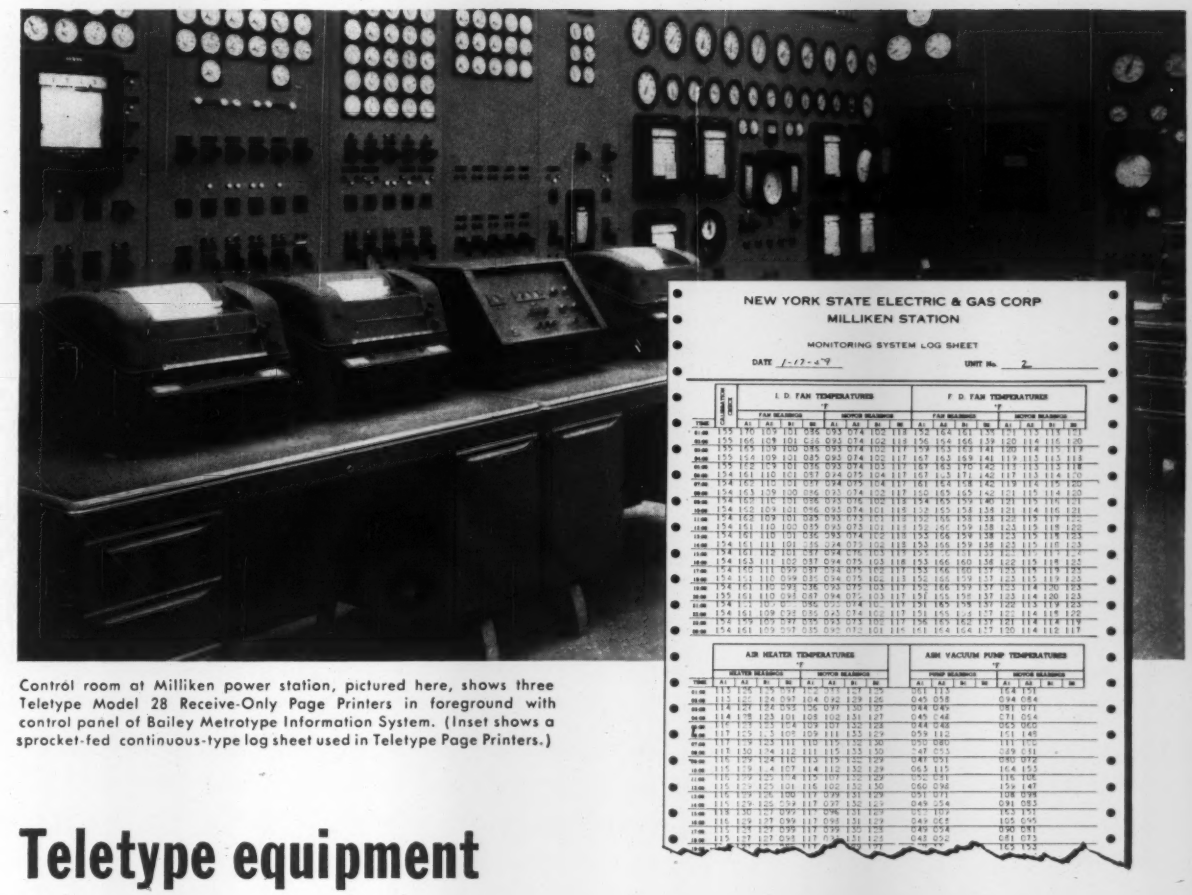
Automatic read-out . . .


NEW YORK STATE ELECTRIC & GAS CORP
MILLIKEN STATION
MONITORING SYSTEM LOG SHEET
I. D. FAN TEMPERATURES
F. D. FAN TEMPERATURES
AIR HEATER TEMPERATURES
AIR VACUUM PUMP TEMPERATURES

Control room at Milliken power station, pictured here, shows three Teletype Model 28 Receive-Only Page Printers in foreground with control panel of Bailey Metrotype Information System. (Inset shows a sprocket-fed continuous-type log sheet used in Teletype Page Printers.)

Teletype equipment monitors and records power station performance

New Model 28 Teletype Page Printers and Tape Punch equipment provide a continuous, dependable data processing facility for evaluating power station performance. This Teletype communication equipment is part of a Bailey Meter Company Metrotype® Information System installed recently at the Milliken power station of the New York State Electric & Gas Corporation, near Ithaca, New York.

This installation consists of two data systems:

1. A Monitoring System that continuously scans a total of 282 variables—temperatures of fan, motor and pump bearings; pressures of water and oil pumps, etc. Whenever readings exceed prescribed limits, system immediately reads and prints complete digital data of off-normal operation. In addition, complete readings are printed hourly.

2. A Performance System that scans 66 points once every hour, measures generator output, main steam flow, feedwater flow, temperatures, etc. All factors required to evaluate the station's performance are logged on the Teletype Printers. A Teletype Tape Punch also produces a perforated tape for IDP.

Robert Darke, Systems Division Manager, Bailey Meter, says, "Teletype equipment was chosen for this installation because of its flexibility and proven reliability. Design is simple and trouble-free, and the units are manufactured specifically for round-the-clock rather than intermittent service."

Teletype equipment will handle data for virtually any purpose in any industry. Signals may be serial or multi-wire. Signal medium may be local electrical circuit, telegraph or telephone circuit, or radio.

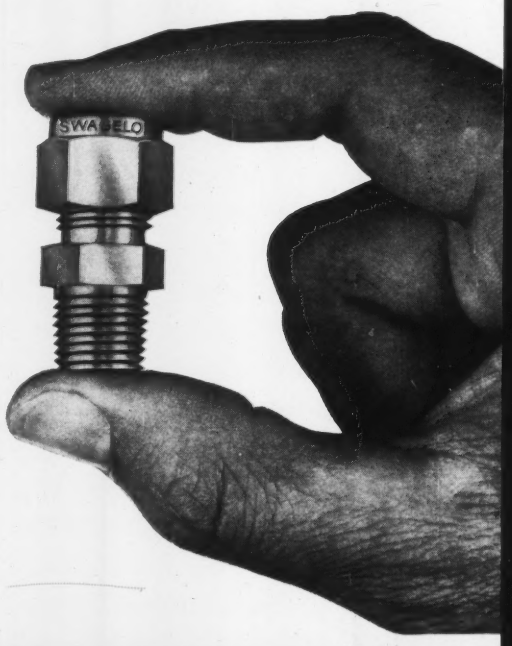
Why not find out how Teletype equipment can fit into your systems plan? Please write: Teletype Corporation, Dept. 23-H, 4100 Fullerton Ave., Chicago 39, Illinois.

TELETYPE®
CORPORATION
SUBSIDIARY OF *Western Electric Company* INC.

CIRCLE 61 ON READER-SERVICE CARD

Swagelok® engineers believe
that NO fitting is too good if it keeps your plant in operation

A tube fitting is small in size but large in importance when you consider that the most minute leak in a system can cause the shutdown of a multi-million dollar plant. Swagelok Tube Fittings represent more than a mechanical necessity. **They are an investment in security**... the type of solid security which results from the use of the finest fittings assuring constant trouble-free, leak-proof operation.



Crawford Fitting Company • 884 East 140th St. • Cleveland 10, Ohio
Crawford Fittings (Canada) Ltd., Niagara Falls, Ontario, Canada

CIRCLE 62 ON READER-SERVICE CARD

Wide Bandwidth with True Differential Input

▸ Only Epsco Instrumentation Amplifiers give you all these features...

- **WIDE BANDWIDTH** . . . dc to 150 kc at gain of 100
- **TRUE DIFFERENTIAL INPUT** . . . true balance, low capacity
- **HIGH COMMON MODE REJECTION** . . . 200,000 to 1 dc . . . 50,000 to 1 ac
- **HIGH GAIN** . . . selectable gains of 100, 200, 500, 1000, 2000
- **HIGH STABILITY** . . . drift less than 2 μv per day; less than 5 μv long term cumulative drift
- **LOW NOISE** . . . less than 3 μv rms to 50 cps
- **HIGH POWER OUTPUT** . . . $\pm$20 volts, up to 40 ma
- **100,000 OHM INPUT IMPEDANCE**
- **FAST RISE TIME** . . . 2.3 μsec. for full scale step input at gain of 100
- **WIDE DYNAMIC RANGE** . . . unsaturating at twice nominal output
- **NO ADJUSTMENTS OR CALIBRATIONS**
- **NO BATTERIES**

With the ever-increasing need for greater accuracy in dynamic instrumentation the demand for an expanding bandwidth in signal amplification becomes more and more urgent. Epsco Instrumentation Amplifiers not only meet the bandwidth challenge, but they also provide true differential input.

Available rack-mounted or in portable units. Write for Bulletin 105801 for complete technical information and options available.

Epsco

First in data control

Epsco, Inc., Instruments & Equipment Division, 275 Massachusetts Ave., Cambridge, Massachusetts

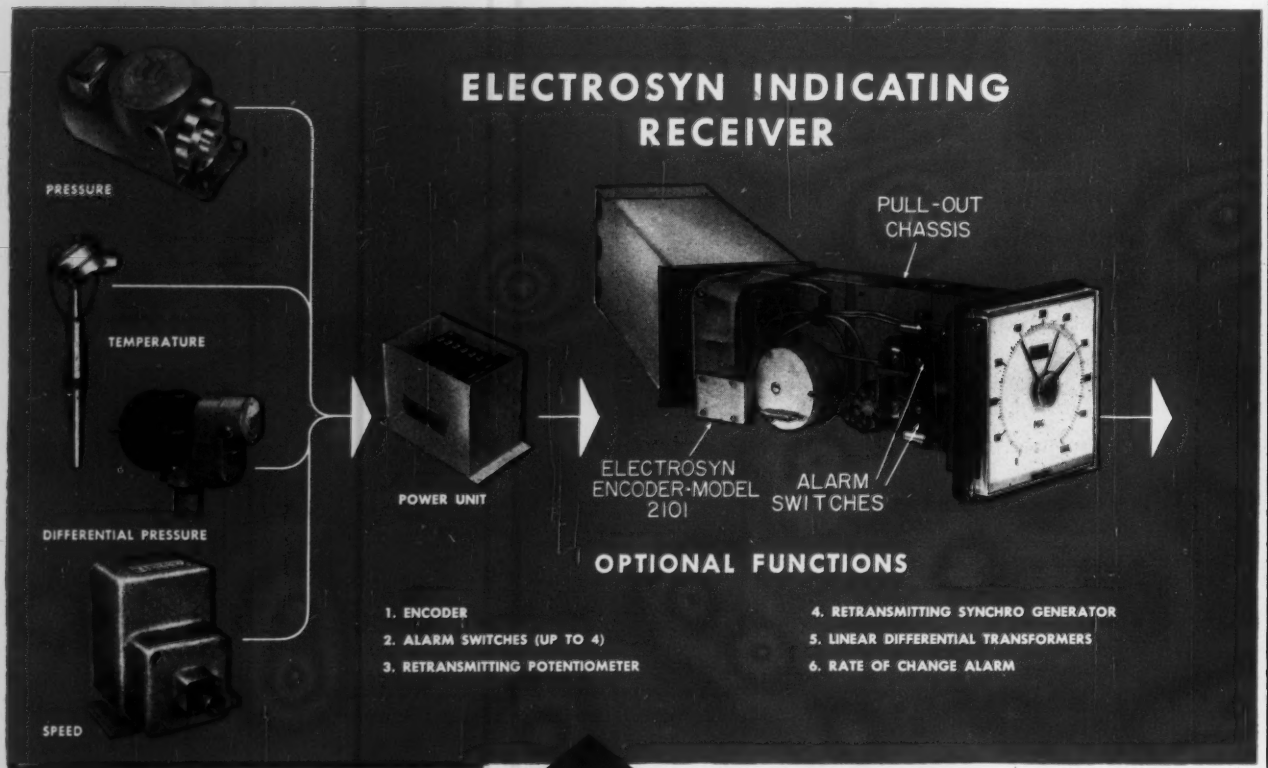
CIRCLE 63 ON READER-SERVICE CARD

3 reasons why Columbia-Gulf

NORWOOD CONTROLS

ELECTROSYN

When Columbia-Gulf Transmission Company engineers first installed digital telemetering equipment on their gas pipelines, Norwood's ElectroSyn System was specified to perform pressure and other measurement and indicating functions. Success of these initial installations has led to repeat orders for ElectroSyn because its low operating and maintenance costs (plus high reporting accuracy) far outweigh its somewhat higher initial cost . . . as the following facts indicate.



PROVEN IN ACTUAL SERVICE

The Norwood ElectroSyn system has proved its compatibility with the leading digital telemetering systems and supervisory control systems. Actual installations are currently helping to cut operating costs for the following well-known users:

SERVICE PIPE LINE CO., TEXAS EASTERN TRANSMISSION CORP., COLUMBIA-GULF GAS TRANSMISSION CO., EL PASO NATURAL GAS CO., SOUTHERN PACIFIC PIPE LINES, INC., ARABIAN AMERICAN OIL CO., LAKEHEAD PIPE LINE CO.

The System

Error signal is amplified by a magnetic servo-amplifier (which can be located up to 4 miles from transmitter). Signal voltage is compared with output from a servo-motor driven feedback ElectroSyn Signal Generator. Pointer on indicator turns until signal and feedback balance and then entire system ceases to move until next transducer signal change.

Write for ElectroSyn Bulletin B258C Norwood Controls Unit, Detroit Controls Division, 937 Washington St., Norwood, Massachusetts.

CIRCLE 64 ON READER-SERVICE CARD

Transmission Company specified

RELIABILITY

No vacuum tubes, no brush contacts, no moving parts at all under equilibrium conditions. Wear due to friction is so much reduced that truly automated pipeline monitoring and control become both practical and economical.

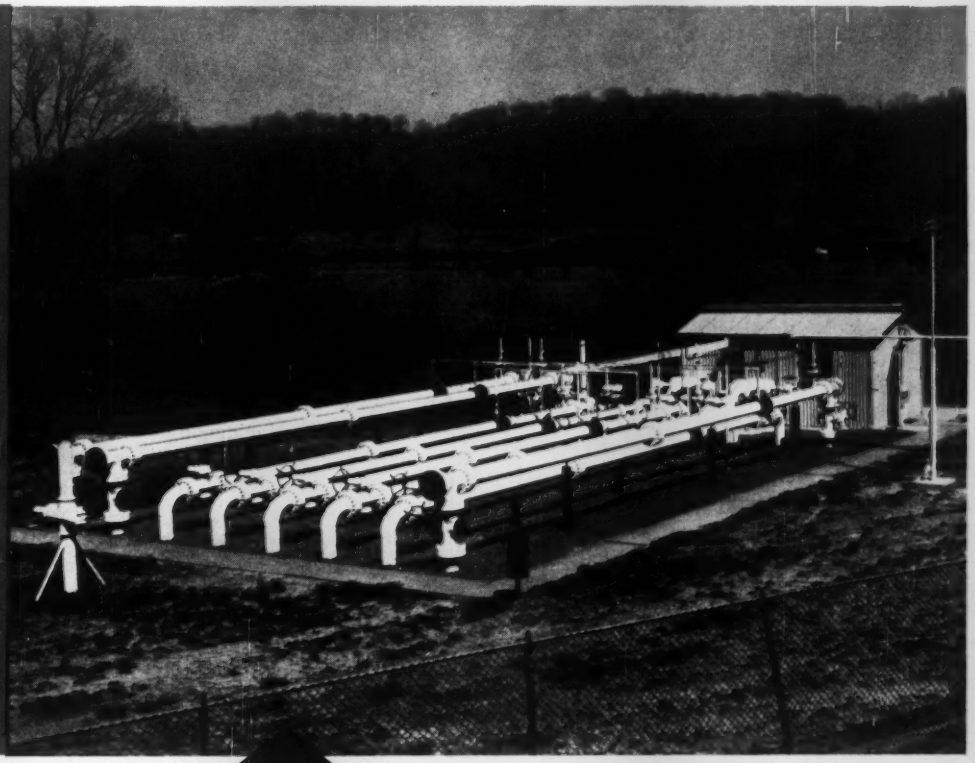
ACCURACY

Pressure, flow and other data are reported with close to 1% of full-scale accuracy. This not only permits lower safety margin requirements and greater throughput under conditions of high demand but also ensures maximum operating efficiency at lower pipeline pressures.

ECONOMY

results from both accuracy *and* reliability. ElectroSyn's trouble-free operation virtually eliminates breakdowns common in less reliable systems and also saves the cost of rushing repair personnel to remotely located stations.

AUXILIARY INDICATOR
(SYNCHRO RECEIVER)



The Pay-off!

In remote locations like this Columbia-Gulf Transmission Company station at Leach, Kentucky, it usually takes many hours to get repair personnel to the job in the event of breakdown. ElectroSyn reliability virtually eliminates the costs of both repair and downtime. Routine maintenance costs are slashed, too.

AMERICAN-Standard
DETROIT CONTROLS DIVISION

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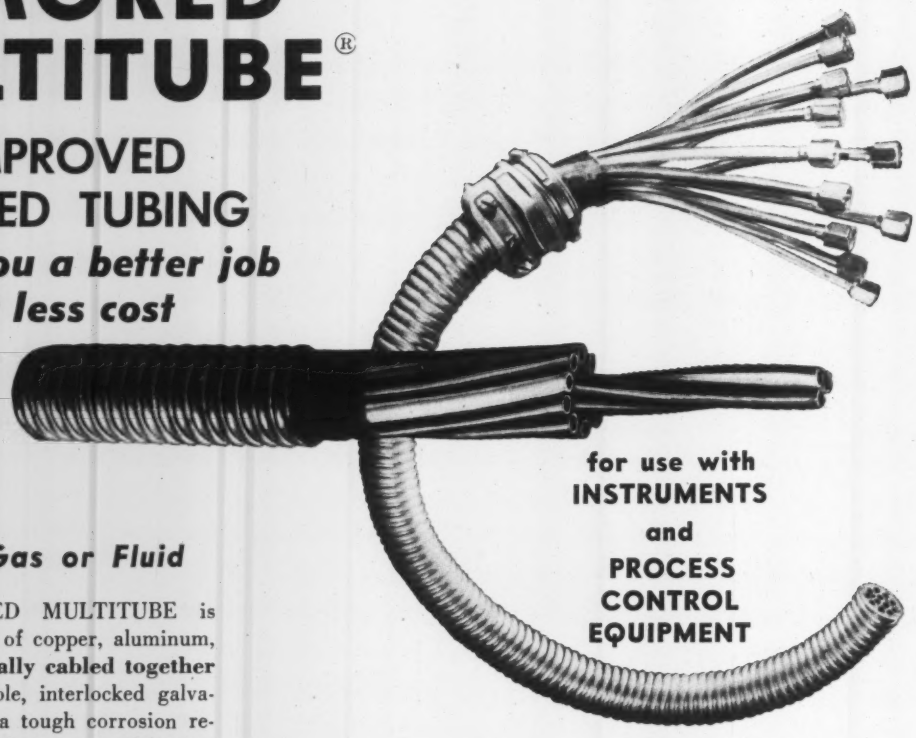
CRESCENT ARMORED MULTITUBE®

IMPROVED CABLED TUBING

gives you a better job at less cost



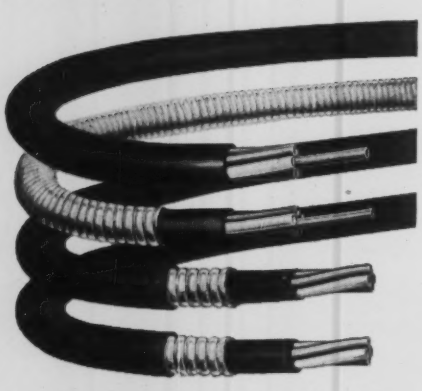
Carries Air, Gas or Fluid

CRESCENT ARMORED MULTITUBE is a group of 2 to 37 tubes of copper, aluminum, steel or polyethylene **spirally cabled together** and protected by a flexible, interlocked galvanized steel armor, or by a tough corrosion resistant thermoplastic sheath, or a combination of both (see below).

The SPIRAL CABLING of the tubes permits easy bending to a small radius without distortion of the tubes. It can be installed with great saving in time.

Special constructions are available for underground runs. This product is licensed under U. S. Patent 2,578,280.

CRESCENT ARMORED MULTITUBE completely out dates the old method of using single tubes, with users reporting *savings in installed cost of* from two to five times the cost of the multitube. In addition, the MULTITUBE system will result in fewer connections and fittings, lower costs for supports or racks, ease of mounting and less space.



FOUR CORROSION-RESISTANT TYPES

A plastic jacket of polyvinyl chloride over SPIRALLY CABLED copper or aluminum instrument tubing provides complete moisture and corrosion protection for the tubes. Flexible galvanized steel armor in various combinations, as shown, gives maximum protection for permanence. Available in size ¼" O.D. in lengths to 1000 feet in from 2 to 37 tubes.

Plastic Coated Single Tubes, copper or aluminum, should be used to give corrosion protection to all single lines up to the final tube fitting, where trouble from corrosion may occur.

SEND FOR BULLETIN 458-A GIVING COMPLETE INFORMATION AND ENGINEERING DATA

CRESCENT INSULATED WIRE & CABLE CO.

Trenton 5, New Jersey

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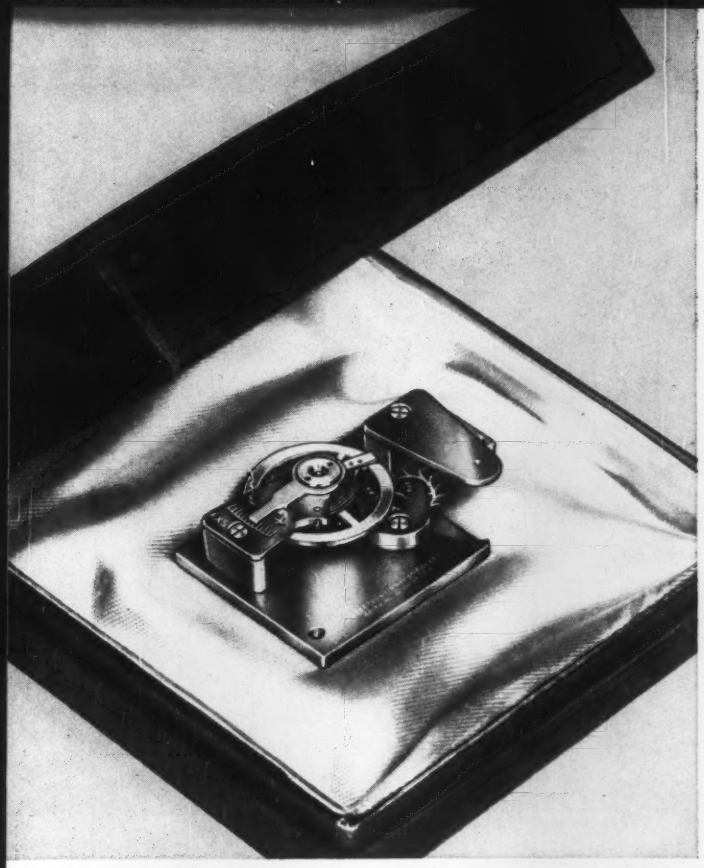

Now there's a New "Jeweled" Escapement in ROCKWELL CHART DRIVES

for greater accuracy and longer life

This jeweled movement brings fine watch quality to instrument timing

The introduction of a jeweled movement—the first ever used on a general industrial timing device made in the United States—makes the Rockwell more accurate than any unjeweled chart drive could possibly be. In addition to offering fine watch quality, the jeweled escapement requires less power to operate and is extremely durable, since seven hard jewel surfaces are provided to limit friction and wear.

You will benefit in many ways by using these jeweled movement chart drives for powering all your recording instruments. They adapt readily to fit into practically any instrument case while speed-changing turrets (see left) permit changing rotation rates at will. Write for full information. Rockwell Manufacturing Company, Instrument Division, Pittsburgh 8, Pa.

SPEED CHANGING TURRETS PROVIDE SEVEN DIFFERENT ROTATION RATES

The basic Rockwell Chart Drive has a main arbor rotation rate of 7 days. Economical snap-on turrets permit changing to 8-day, 15-day, 16-day, 24-day, 30-day, 31-day, and 24-hour rotation. No tools or special skills are required. You can even change chart rotation without removing the drive from the instrument.

JEWELED CHART DRIVES

another fine product by

ROCKWELL

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where accurate, dependable records are a **MUST**

ROCKETDYNE looks to DYNALOG* Electronic Recorders

Test-firing is a vital function at Rocketdyne, a division of North American Aviation, Inc. Rocketdyne manufactures liquid propellant rocket engines for the Army's Redstone and Jupiter missiles; the Air Force Atlas and Thor.

Critical data on engine thrust, temperature, valve operation, and many other performance characteristics are recorded by a remote battery of 150 Dynalog Electronic Recorders.

Dynalogs fit Rocketdyne's instrument requirements to a T: accurate within ±¼% of full scale, one second pen sweep, high input impedance. And because Dynalogs have no slidewire, Rocketdyne finds their maintenance problems practically eliminated. They prefer circular charts also, for faster, easier analysis of each measured variable after a test firing.

Rocketdyne is presently using over 1,000 Dynalog Recorders. Find out how Dynalog Instruments can improve recording and control of your process. Write for Bulletin 20-10.

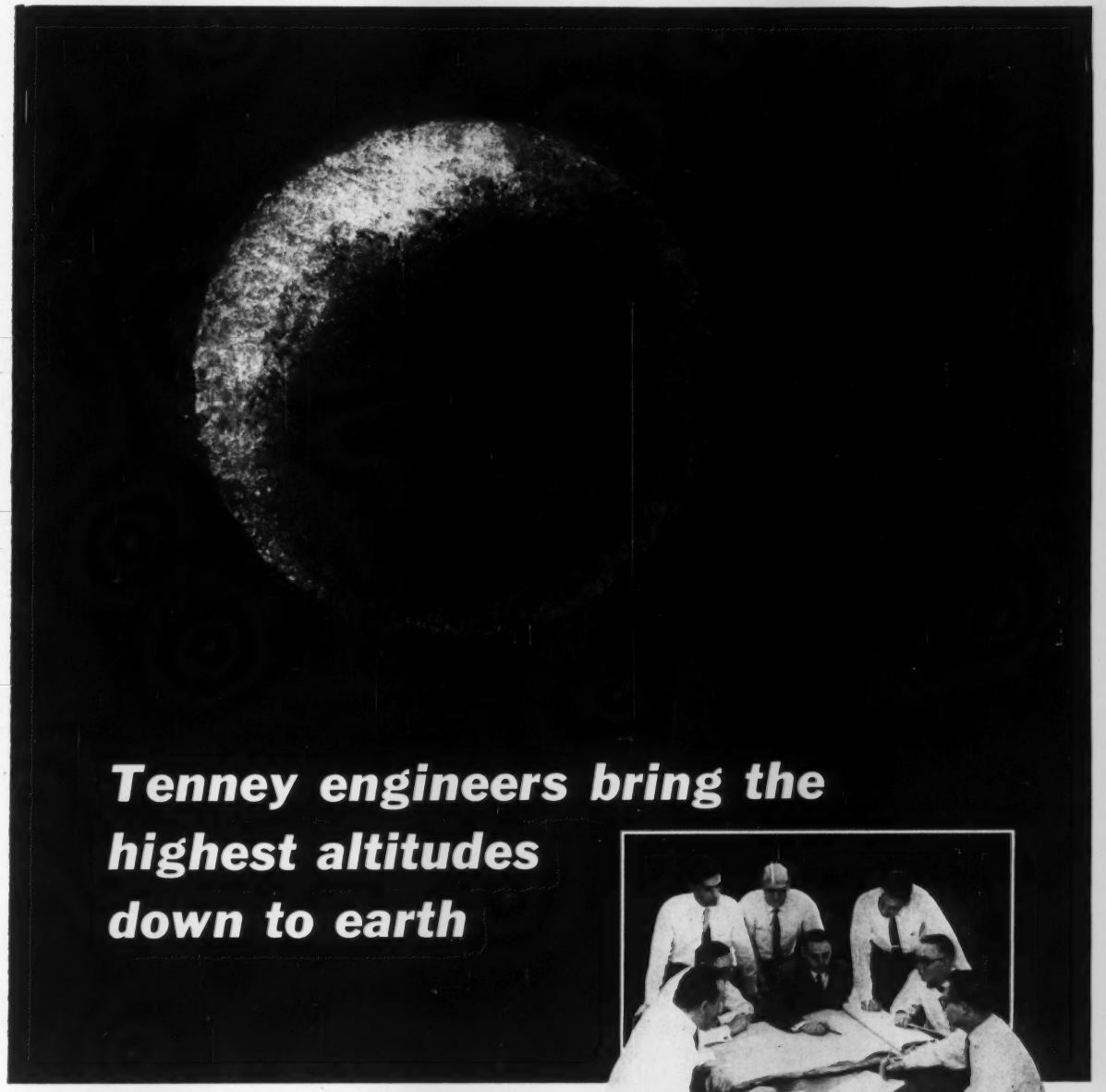
The Foxboro Company, 468 Norfolk Street, Foxboro, Mass.

*Reg. U. S. Pat. Off.

Some of the 150 Foxboro Dynalog Recorders used at Rocketdyne's Propulsion Field Laboratory. During each test, these instruments log critical items of information with split-second timing and exacting accuracy.

At the most extensive rocket research center in the Free World, Rocketdyne engines undergo full-scale tests on this giant static test stand. Power developed by rocket engine is being measured in remote control center.

FOXBORO
REG. U.S. PAT. OFF.



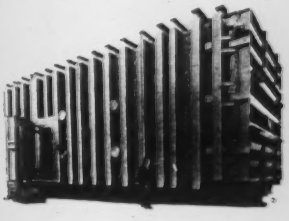
Tenney engineers bring the highest altitudes down to earth

What happens to men or machines at 200,000 feet...or 400,000 feet...or 600,000 feet...or ???

Tenney Engineering has pioneered in the development and manufacture of environmental chambers that simulate the extreme conditions encountered at exceptionally high altitudes. No other engineering group has as much combined experience in this particular activity.

If the rigors of high altitude must be met by your products, investigate the environmental chambers, standard or custom-designed, manufactured by Tenney, world leader in environmental equipment. Write for complete information.

Tenney
ENGINEERING, INC.



1090 SPRINGFIELD ROAD, UNION, N. J. PLANTS: UNION, N. J. AND BALTIMORE, MD.

OLDEST AND LARGEST MANUFACTURER OF ENVIRONMENTAL EQUIPMENT

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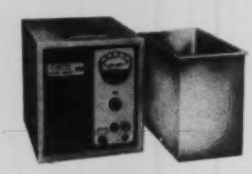
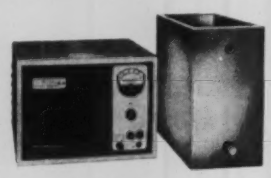
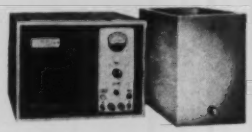


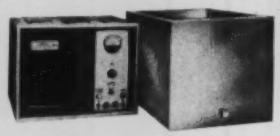
Model BC60
Capacity 1¼ gal. **$350**



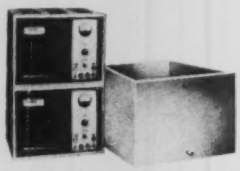
Model BC125
Capacity 2 gal. **$575**



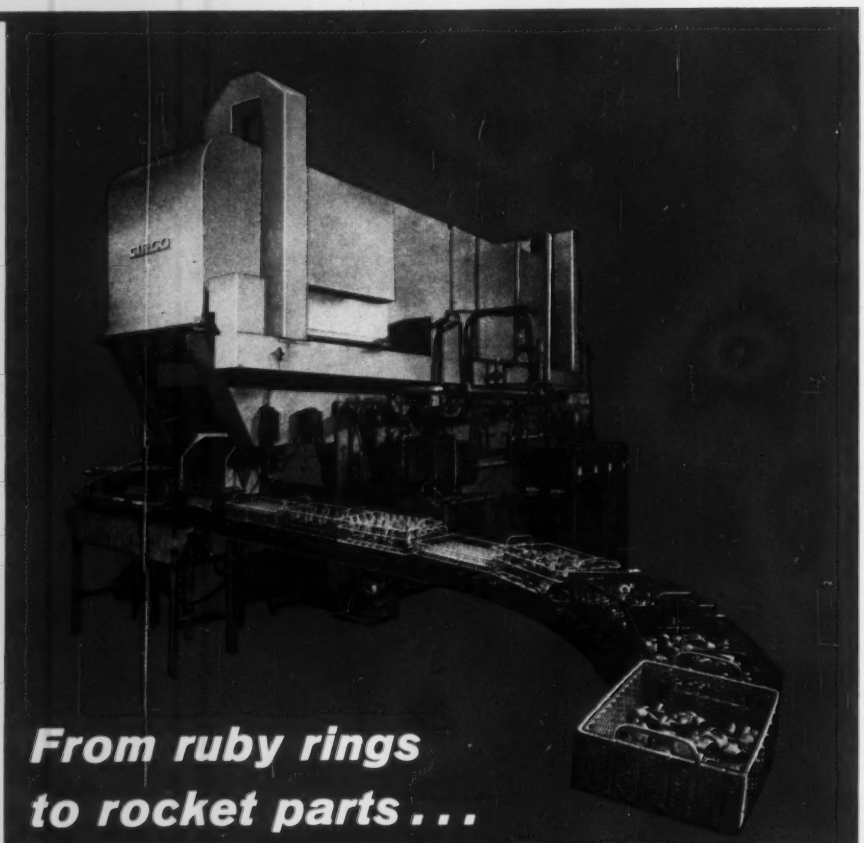
Model BC250
Capacity 5 gal. **$750**



Model BC500
Capacity 12 gal. **$1375**



Model BC1000
Capacity 25 gal. **$2750**



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Whenever *absolute* product cleanliness is a critical factor . . . whenever cleaning is a production bottleneck . . . CIRCO ultrasonics offer you the widest range of precision engineered ultrasonic cleaning units available anywhere.

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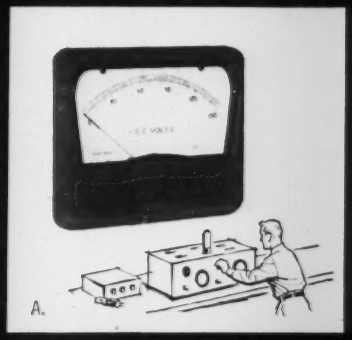
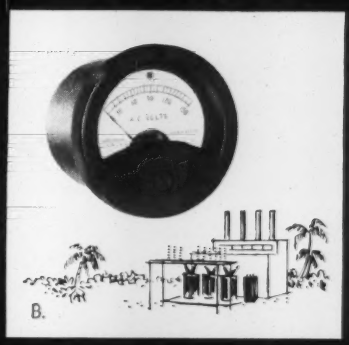
A HALF CENTURY OF QUALITY AND DESIGN ACHIEVEMENT

from simple tube-testers to complex missile tracking gear



A.



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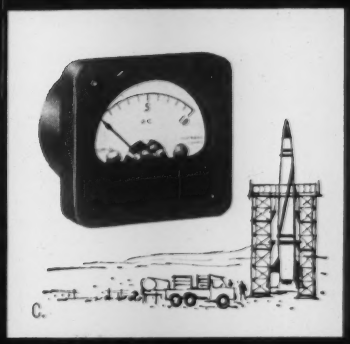

C.

Federal Pacific's precision panel instruments

serve industrials...utilities...national defense

A. Typical commercial unsealed bakelite panel instrument. B. Sealed bakelite model for use in severe conditions of dust, humidity, or corrosive atmosphere. C. Ruggedized model designed to withstand high shock, severe vibration of military and other rough duty applications.

FEATURES: ■ ALUMINUM ALLOY DIAL—Printed by special process over fume resistant paint. Withstands moisture and atmospheric effects. Graduated for high readability ■ ALNICO MAGNET—High coercive force Alnico magnet material minimizes weight, increases field strength ■ SELF CONTAINED RUGGEDIZED MODELS—Solder and gasket sealed with shock mounts inside... provides complete isolation of all internal parts from impact on case ■ IDENTICAL HIGH QUALITY—Commercial models manufactured to same high standards demanded for military production.

Using the engineering skill and design know-how that comes through long and valued experience... Federal Pacific's Instrument and Relay Division, Fifty Avenue L., Inc., carries on the tradition of quality manufacture built through half a century of progress as the Roller-Smith Corporation. For complete details, write for Bulletin 3-15, Federal Pacific Electric Company, Dept. 375, Newark 1, New Jersey.

FPE **FEDERAL PACIFIC ELECTRIC COMPANY**

The Best in Electrical Distribution and Control Equipment

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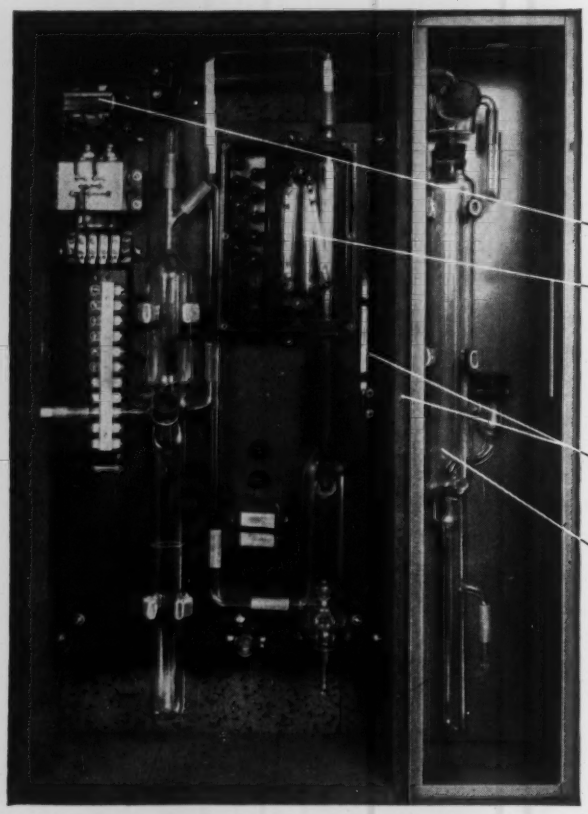
Gas Analysis a problem?

SOLVE IT PERMANENTLY WITH EQUIPMENT WHICH GIVES YOU THESE 7 ADVANTAGES



Thermal Conductivity Analyzer

In hundreds of plants, L&N's Thermal Conductivity Gas Analyzers are solving the problem of obtaining accurate, reproducible measurements of CO_2, SO_2, H_2 in N_2 and many other gases. Because they embody the benefits of thirty years' experience in process gas analysis applications, L&N Thermal Conductivity Analyzers . . . . .

1. Eliminate gas measurement upsets. A constant voltage regulator excludes a-c power variations.

2. Provide accurate measurements by using the unique L&N cell design which gives you vibration-free operation due to a rigid filament support . . . electrical stability by using a platinum filament . . . high corrosion resistance due to glass coating of the filament . . . and immunity to small flow variations because the cell is designed to utilize the gas diffusion principle.

3. Make reproducible measurements possible. Ambient temperature swings are eliminated by enclosing cell assemblies in an insulated case with thermostatically-controlled temperature.

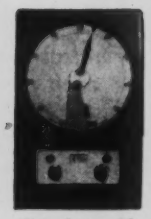
4. Permit low maintenance and therefore minimum downtime as a result of the time-tested analyzer design including features such as flexible junctions, heavy glass construction, etc. Coal and asbestos filters remove mist and dust to assure cleanliness of the analyzer system.

5. Match the inherent accuracy and sensitivity of null-balance Speedomax®G and H Recorders.

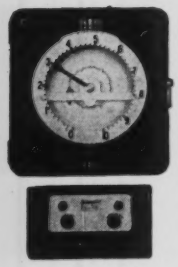
6. Permit selection of the particular type of control forms to fit the process. These include electric control, electro-pneumatic, and all-pneumatic controls—each designed to work with the Analyzer-Recorder system for maximum throughput.

7. Gives you undivided responsibility. The entire thermal conductivity system . . . sampling system, analyzer, recorder-controller . . . is designed, engineered and built by one organization with a nation-wide sales and service staff.

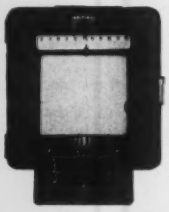
These "plus" features of L&N's Thermal Conductivity Gas Analyzers can help satisfy your demands for top quality products which lead to substantial savings. An eight-page booklet, Folder ND46-91(6) giving data on this equipment, is available by writing to Leeds & Northrup Company, 4955 Stenton Avenue, Phila. 44, Pa.



Speedomax H Series 60 Electric Control



Speedomax G Series 60 Electro-Pneumatic Control



Speedomax G Pneumatic Controller

LEEDS NORTHRUP
Instruments Automatic Controls • Furnaces

CIRCLE 71 ON READER-SERVICE CARD

editorial

SOVIET INSTRUMENT MANUFACTURE

K. ARUTYUNOV

Planovoe Khozyaistvo 1958 Vol. 8 29-39.

(ABRIDGED)

The progress of science and modern technology is intimately bound up with the development of instrument production and improvements in the methods and means of measurement and control and regulation of manufacturing processes. It is no exaggeration to say that increasing productivity is largely determined by instrumentation developments and that the automation of industrial processes is essentially dependent on up-to-date, accurate and reliable instruments.

The increasing importance of industrial instruments is indicated first by the rapid growth of the instrument industries in many foreign countries, and secondly by the constant increase in the ratio of the cost of instruments and automatic equipment to the total cost of industrial plant.

For instance, while the total volume of industrial production in the U. S. A. during the period from 1950 to 1956 increased by 27 per cent, instrument production was doubled. The difference was even greater for the period from 1939 to 1956, during which time the volume of industrial production was roughly doubled and instrument production was increased by 10 to 12 times. According to information provided by German specialists at the International Automation and Instrumentation Congress in Dusseldorf, the cost of instrumentation and automation in the construction of new power stations is 7 to 10 per cent of the total capital expenditure, and in the chemical industry generally instruments account for 15 per cent of the cost of new plants.

The production of instruments in the U. S. S. R. (apart from special instruments) increased 5.2 times during the period 1950 to 1957, but in spite of this the increasing industrial demand is not being fully met. The 20th Congress of the Communist Party outlined a programme for a wide-scale adoption of automation of industrial processes in the main branches of industry, and an associated increase in the output of instruments of 3.5 times. The building of 32 new instrument manufacturing works is contemplated.

Automation experience shows that in most cases the initial cost of automation is recovered in about 18 months. The automation of industrial processes has an enormous economic effect. In coal mining, the food industry, transport and communications alone, automation will release more than 500,000 people for more productive work elsewhere. In addition to reducing the number of personnel employed automation ensures an increase in plant productivity of 10-20 per cent (on an average), it reduces the consumption of raw materials, fuel and electricity, and saves millions of roubles of public money.

At the Efremovsk synthetic rubber factory automation of plant for catalytic decomposition of alcohol resulted in an 18 per cent reduction in the labour force, an annual saving of 570 (metric) tons of alcohol, and a reduction in consumption of 150,000 puds (= 2460 metric tons) of grain used for the production of the alcohol. From the amount of alcohol saved 50,000 motor car tyres could be made. The cost of the automation of this plant was recovered in 2½ months. Many more examples of this kind could be cited.

Steps must be taken immediately to develop the productive capacity of the instrument industry if the present shortage of instruments and automation apparatus is not to become a serious obstacle to the widespread adoption of automation. During 1959-1965 it will be necessary to speed up the development of the instrument industry to ensure a quadruple increase in the over-all output of instruments, and this expansion must include 8 to 10 times increase in control and regulating instruments, and a tenfold increase in the output of computing equipment. In addition to a mere quantitative increase, quality must also be improved.

Flowmeters

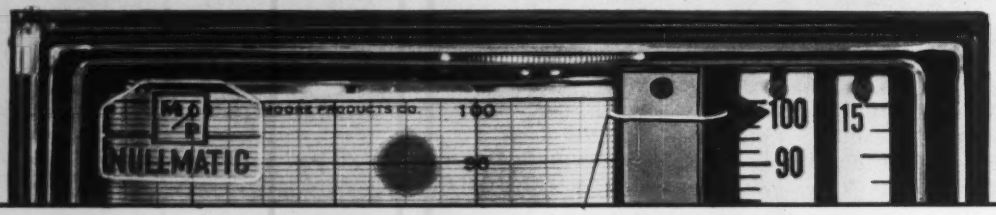
The instrument industry faces the problem of organising the manufacture of a normal series of rotameters, volume meters and differential pressure gauges for use under different conditions. Remote and direct reading types are needed. In certain instances the sensing element cannot be allowed to come into direct contact with the measured medium, and for these special conditions flowmeters using ultrasonics and radioactive radiation must be developed and pro-

From *LLU Translations Bulletin*, Jan. 1959, Dep't of Scientific and Industrial Research, London.

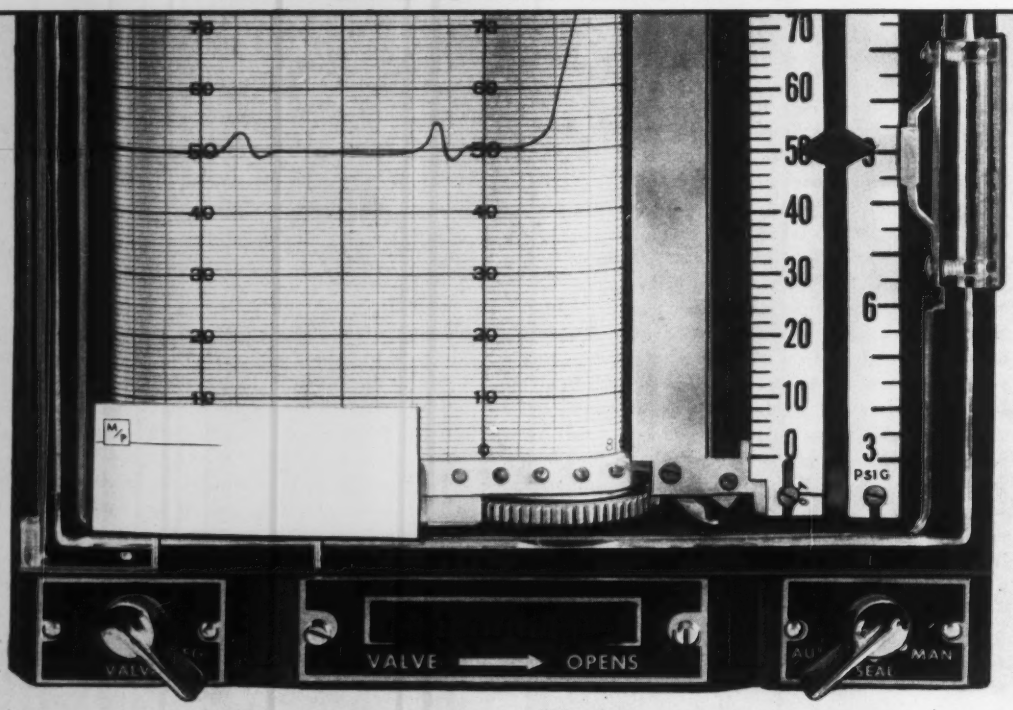
We did it for the plant operators . . .

We're sure they will like this

NEW M/P RECORDING CONTROLLER



with SIGNAL LIGHTS



See it—and the largest line of recorders,

indicators and controllers—at booth 105

MOORE PRODUCTS CO., PHILADELPHIA 24, PA.

CIRCLE 72 ON READER-SERVICE CARD

duced. With the construction of new oil refineries and synthetic fatty acid factories a large category of new instruments will be required even in 1958. These include recording flowmeters for use in pipelines of 80, 150 and 250 millimetres. Presently available instruments will only handle flow diameters of 40 millimetres.

Instruments For Automatic Chemical Analysis

Automation of analytical control would release many routine analysts (20,000 in the chemical industry) for more productive work, and a considerable additional saving would accrue from the improved control of technological processes which would automatically ensure the more efficient utiiisation of raw materials and plant.

Instrument manufacturers are faced with a problem of considerable magnitude, i.e. that of evolving and producing an extensive range of apparatus for the analysis of gaseous and liquid substances, based on conventional methods of measurement: thermal conductivity, thermal effect of combustion and optical-acoustic, thermochemical, magnetic and other methods. In addition it will be necessary to design and produce other instruments for automatic chemical analysis which must utilize known laboratory analytical methods, e.g. photocolorimetry, refractometry, mass spectrometry, chromotography and magnetic nuclear resonance.

Control Systems

One of the principal shortcomings in our instrument industry is the lack of standardisation of instruments, primary control elements and controllers. For example, at the present time an integrated control system is being built which is constructed on the block principle, but which is not yet fully equipped with the necessary primary control elements and converters. Such problems will occur frequently in the course of the next few years, and the instrument industry must learn how to overcome them.

Work on the production of an electrical control system has already been in progress for several years at the Institute of Automatics and Telemechanics of the U. S. S. R. Academy of Sciences, the Scientific Research Institute for the Production of Thermal Power Engineering Instruments and a number of other establishments. It would be desirable to entrust the organisation of the manufacture of electrical control systems to the Moscow Council of National Economy. Production could later be handed over to the new instrument factories.

With the development of automation a transition is taking place from the integrated control of individual process parameters to the integrated control of a number of interrelated parameters. New control methods have been and are being developed whereby it is possible not merely to maintain a controlled parameter at a specified value, but to vary the process conditions in accordance with preselected optimum conditions.

For speedy adoption of these control methods on a wide scale it will be necessary to develop and organise the manufacture of special devices: High-speed controllers with correcting elements, multi-channel and multi-range controllers for a number of parameters, and self-adjusting and self-varying controllers for the control of technological processes in the optimum conditions.

Extensive use has been made recently of digital methods of indicating and recording measured magnitudes; such methods eliminate errors of calculation and facilitate transmission of the measured results to locations remote from the controlled process where they can be readily evaluated. Combined with scanning and "interrogating" devices, these methods reduce the cost of automation and facilitate the establishment of centralised process control. However, centralized control is not without its difficulties. For example, the increase in the number of controlled and regulated variables has resulted in an unacceptable increase in the size of the central control panel and the number of instruments on it. This has made it essential to design miniature instruments and special purpose display panels. Automatic group recording apparatus is also useful and in recent years a number of organisations, including the Independent Technological Design Office for Biophysical Apparatus "SKTB-BFA" and the Scientific Research Institute for Calculating Machine Construction, have been successfully engaged on the design of such apparatus. The work has not yet gone beyond the experimental stage, but production of automatic recording apparatus should begin during the current year at the factories of the Moscow Council of National Economy.

Regulators

A standard series of pneumatic (diaphragm and piston), hydraulic and electrical (with and without contacts) final control mechanisms for different powers is required. Currently, we have no such standardised series. A small quantity of such equipment is produced but it is often of obsolete design and not very well standardized. The Special Automatic Equipment Design Office at Kirovakan in the Armenian S. S. R. is developing a standard series of electrical regulator mechanisms, and the Chuvashsk Council of National Economy will organise their manufacture at the Cheboksarsk Factory.

Something must also be said about the production of other types of regulating equipment—rotary valves, slide valves and other shut-off devices. The majority of such equipment, as manufactured at present, is unsuitable for remote control and automatic control. It is often impossible to automate industrial processes simply because there is no shut-off and regulating equipment. In the chemical industry for example tens of thousands of workpeople are engaged on the unproductive labour of closing and opening valves, slides, etc., sometimes in diffiicult and dangerous conditions. The Central Equipment Design Office and Equipment Manufacturing Works should take immediate steps to increase the output of shut-off and regulating fittings and equipment, suitable for automatic control.

Telemetering Equipment

Telemetering equipment permits a reduction in attendant personnel and increases plant utilisation and

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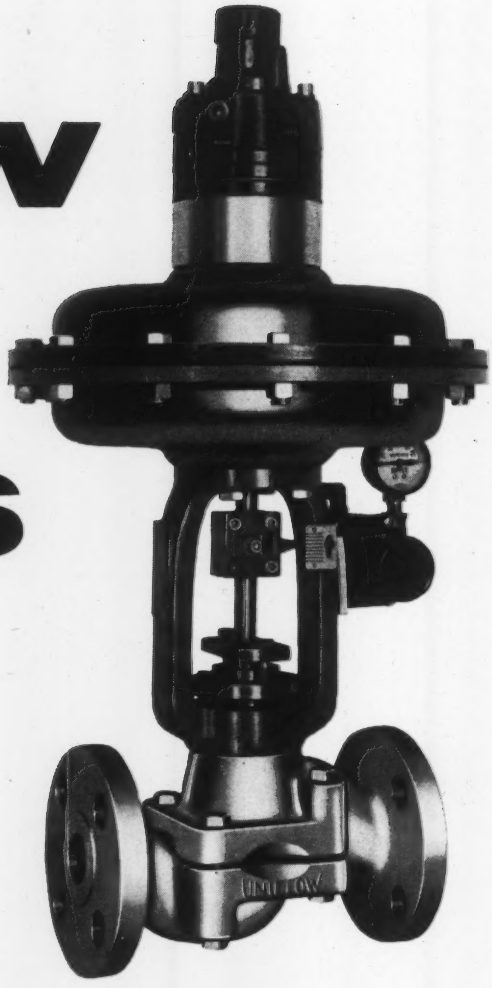

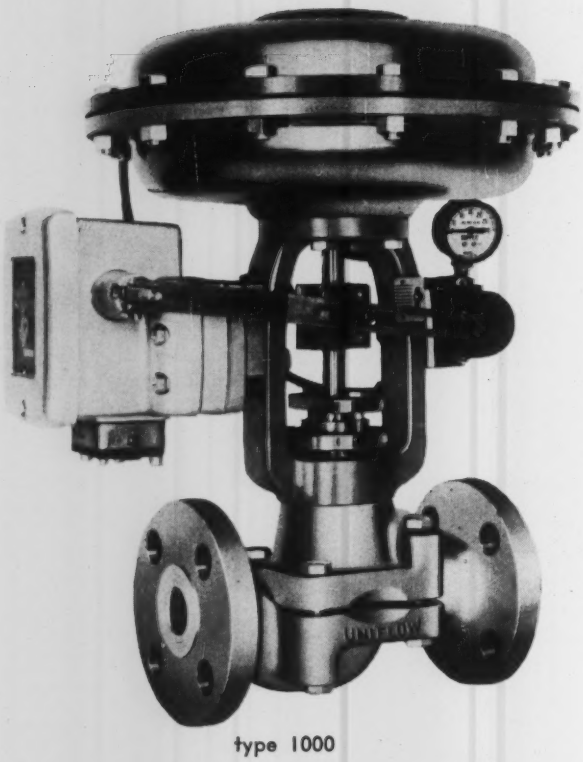

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efficiency, but lack of the necessary equipment is delaying its introduction into the national economy. In point of fact telemechanisation has been applied on a relatively wide scale only in power generating systems. To cover the needs of other industries the output of telemetering equipment should be increased by 10-12 times by 1965. To accomplish this much research and development remains to be done, and in our opinion this work should be undertaken by the Central Scientific Research Institute for Complex Automation.

Computing Equipment

One of the most significant events of the last decade was the appearance of electronic digital computers. As well as making possible the solution of complex mathematical problems, computer techniques open up immense possibilities in the field of automation. For example real-time control at last becomes feasible. Councils of National Economy should ensure the speediest action and the organisation of greater production facilities for computers should be arranged.

Production plans should provide for:

(a) large scale general purpose digital computers with a speed of from 2,000 to 20,000 operations per second, with automatic programme control. These machines will have extensive application in planning and in scientific research organisations;

(b) small scale electronic digital computers for a wider circle of users;

(c) a standard series of electronic analogue computers.

Special fast machines must also be developed for the solution of multi-dimensional problems of modern physics and engineering. They must be capble of performing more than 100,000 operations per second.

In the field of automatic control a fundamental problem is the coordination of the results of the work of engineers, mathematicians and instrument makers. The primary control instruments they develop can be combined into practical control systems but computers provide the means of testing control systems before they are actually constructed. In many cases the simplest computers will suffice and these may be readily constructed if standard computing elements are readily available. The increasing complexity of industry has given rise to a simultaneous increase in routine clerical work. Although computers have been used extensively in such work abroad, little has been done in this country. There is also a lack of standard punched card equipment.

Instruments and Automation Economics

The economic expediency of effecting automation in industry will depend largely upon the cost, reliability, quality and accuracy of the automatic equipment employed, and serious attention must be directed to increasing the reliability and quality of instruments. The important requirement, however, is not observed in a number of cases in the instrument manufacturing industry. For instance, the Tomak pressure gauge factory and the Kazan "Teplokontrol" factory are producing pressure gauges, manometric thermometers and direct-acting regulators with a service life of only 6-10 months. Doubling the reliability and service life of instruments such as these is equivalent to a similar increase in the output of instruments for the same productive floorspace.

The cost of automation of industrial processes is directly proportional to the cost of the instruments and automation equipment. The cost of many instruments is still high and is delaying the extensive introduction of automatic equipment in industry. Serious attention must be given to improving the technology and introducing continuous methods of production and full automation in the manufacture of instruments. There are some outstanding instrument factories—for example, the Moscow factory "Manometer", the Lvov instrument factory and a number of other concerns, but generally there is a lack of co-ordination in the work of the various production organisations.

Every organisation and authority has tended to develop and produce small series of "special" instruments for its own needs. Five or six organisations have been engaged on the development of the same types of instrument and have aimed at preserving and strengthening their importance by selecting arbitrarily the input and output parameters of the instruments they produce. Instruments developed by one organization or authority often cannot be used in automation schemes with instruments developed elsewhere. This has resulted in waste of effort and state funds. To correct this, it will be necessary to establish a single State Instrument System which, above all, will ensure strict regulation of the input and output parameters of primary control or sensitive elements, controllers, final control mechanisms and other automation equipment. The single State Instrument System should make provision for the production of standard series of unified primary control elements, secondary instruments, amplifiers, stabilising elements, final control mechanisms with regulating members, and remote transmission elements both for normal use and for use in conditions of corrosive and explosive media. It is necessary to consider the maximum standardisation of automation elements and their block or unit construction elements to make possible their mass production.

Research and Development

In order to ensure the proper development of the home instrument production, a large number of new instruments must be developed. The number of scientists and engineers in this field must be increased several times, for which purpose, in our opinion, vigorous research and design offices should be established at every instrument making works where most of the design work should be carried out.

Existing special design offices and scientific research organisations should be retained and expanded, and their efforts concentrated on the solution of the basic problems: the development of control systems, the search for new, improved methods of measuring and regulating technological parameters, and the development of new instruments and automation equipment based on these new methods. Two new scientific research and design institutes for instruments should be established in the eastern region of the country.

A differential-pressure flowmeter measures a head or the square root of a head. But such a measurement is not a true measure of flowing volume unless corrections are made for conditions in the pipeline.

Automatic Temperature and

AUTOMATIC COMPENSATION of flowmeters for variations in both pressure and temperature is not new. Many industrial users of natural gas have long made it a practice to apply automatic pressure and temperature compensation to gas flowmeters. Compensated flowmeters are growing in importance in automatic combustion and process systems, internal plant distribution, cost accounting, monitoring the general distribution of natural gas flows to various end points, setting up gas distribution, and wherever the time lag involved in the usual practice of planimetering charts of differential pressure and static pressure is not desired.

Automatic compensation for variations in pressure and temperature gives immediate measurement of gas flow in standard cu ft/min, which is available for electrical transmission, either as an analog signal suitable for data logging systems, or in a time-pulse system for long-distance transmisison. Transmitted gas flow measurements then can be integrated automatically to make total gas flow figures available at any instant. It often is desirable to integrate the flow at both the remote and central points.

With greater emphasis being placed on gas distribution, the use of automatic pressure and temperature compensation is becoming more and more prominent in the gas industry.

A novel and exacting application of the compensated gas flowmeter is a Venezuelan installation. Flowmeters there are being used in a surge control system to measure the flowing volume of gas flow through each of a series of five gas-turbine-driven compressors. Natural gas from this field is being stripped and then pumped back into the ground at high pressure. In order to operate the compressors at maximum capacity and peak efficiency, it is necessary to deliver the maximum gas flow possible without sending the compressors into surge or runaway. The surge point is determined by the flowing volume of natural gas, which is subject to errors in measurement due to changes in pressure, temperature, and molecular weight. Thus compensating the flowmeter for these variables permits continuous and accurate measurement of flow volume and provides safe operation of the compressors at a point very near to surge. Several sets of these installations are now in operation, with more scheduled for start-up.

Compensation Principles

The basic flow formula for volumetric flow rate (Q) through an orifice or differential-pressure element is:

$$Q = (\text{a constant})\,(Av)$$

where the constant includes the coefficient of the primary element; A is area of pipeline; v is velocity of the fluid (equal to $\sqrt{2gH}$, where H is differential pressure *in feet of head at flowing conditions*). Thus $Q = (\text{a constant})\,(A)\,\sqrt{2gH} = (\text{a constant})\,(A)\,\sqrt{H}$. As head is desired in inches of water (h) at standard or design conditions, rather than feet of fluid (H) at flowing conditions:

$$H = (\text{a constant})\,(h)\left(\frac{1}{G}\right)\left(\frac{T_f}{T_s}\right)\left(\frac{P_s}{P_f}\right)$$

$$= h\ (\text{a constant})\,(T_f)/P_fG$$

where T_f is absolute temperature of flowing fluid; P_f is absolute pressure of flowing fluid; G is specific gravity of fluid; P_s is standard absolute pressure (14.7 psia) and T_s is standard temperature (520°R). Thus the basic formula becomes:

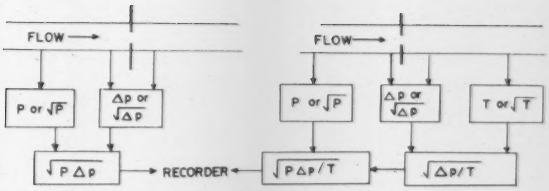
$$Q = (\text{constant})\,(A)\sqrt{hT_f/P_fG} \qquad (1)$$

where Q is *cu ft per hour at flowing conditions.*

Most flow measurements are desired in terms of cu ft of gas at *standard conditions,* requiring a correction for pressure and temperature whenever the pipeline conditions are far removed from standard conditions.

From Boyle's Law, it is know that the volume of

DONALD M. STOUGH
Senior Meter Engineer
Hagan Chemicals & Controls, Inc.



PRESSURE COMPENSATION (left) is most common system; combined pressure and temperature compensation is shown at right.

Pressure Compensation

an ideal gas varies *inversely* with pressure. Hence the simple pressure correction factor (f_p) is (P_f/P_s) where P_f is flowing pressure and P_s is standard pressure.

From Charles' law, it is known that the volume of an ideal gas varies linearly with temperature. Hence the correction factor for temperature is (T_s/T_f) where T_s is standard temperature; T_f is flowing temperature.

Applying both factors to the basic flow equation

$$Q = (\text{a constant})\,(A)\sqrt{hT_f/P_fG}\,(T_s/T_f)\,(P_f/P_s)$$

$$= (\text{a constant})\,(A)\sqrt{hP_f/T_fG} \qquad (2)$$

Note that equation 1 is the basic flow formula for uncompensated flow; equation 2 is the formula for compensated flow.

Techniques

There are two basic techniques for obtaining the compensated signal. One is to multiply the square root of the head signal by the square root of the pressure signal and then divide by the square root of the temperature signal; the other is to multiply the head signal by the pressure signal and the inverse of the temperature signal, then obtaining the square root of the resulting product.

This can be done in several ways, including manual and automatic methods.

The manual method simply divides the chart flow record into intervals of one quarter or one half hour. The average flow in that period is then compensated manually by using the average pressure and temperature during that interval. This technique is laborious and becomes excessively in error where large or rapid variations in flow, pressure or temperature exist.

The next technique uses a square-root planimeter to integrate the square root of the head, pressure and temperature signals, giving an average value for each. If the pressure or temperature varies more than about 10%, however, this technique will result in errors because the *instantaneous* flow signal should be multiplied by the *instantaneous* values of the correction factors.

A semi-automatic method uses an integrator. This instrument rotates the chart while the operator follows the flow curve with one stylus, the pressure curve with another. The instrument automatically multiplies the product and extracts the square root, using a shaped cam.

Automatic techniques for compensation include mechanical and electric methods. The mechanical uses linkages and cams to move the multiplication factor of the flow recording pen so that the flow and pressure (or temperature) signals are effectively multiplied.

The most common electrical methods involve use of a linear variable differential transformer, whose core is positioned by the flow and pressure signals. The signals are multiplied electrically (sometimes by servomultiplier techniques), and the square root can be extracted by using a square-root cam to position the transformer core or recorder pen.

A common temperature-compensation technique is to use a resistance thermometer in a bridge circuit, with a servomoter (cam-driven to extract square root) being used to balance the bridge.

The most versatile compensation systems use combinations of mechanical, electrical, and servo-type devices.

Compensation factors for nonideal gases, such as superexanpansibility, are often included in the compensation circuits.

Location of the sensing elements for pressure are given by the AGA—upstream when using pipe taps; downstream when using flange taps. The temperature element location is not critical as temperature does not change significantly across the orifice.

Compensation Practice

Compensation of a differential-pressure flowmeter signal for the pressure and temperature conditions in the pipeline is now performed either mechanically, pneumatically or electrically, as is seen from this survey of available compensation equipments.

THE FUTURE may see most computational functions performed by electronic computer, and one basic use of process control computers will be the application of compensation signals to flowmeter signals so that true mass flow readings are obtained. But use of expensive computer techniques can be justified only where large numbers of flow signals are to be compensated, or where a computer is already available. Unless these conditions are met, the conventional mechanical, pneumatic, or electric compensation devices shown here will perform the compensation.

American Meter Co.

American Meter Co. orifice meters are of the type shown in Fig. 1. The float motion turns a shaft, which is the head signal. The head signal is usually recorded along with a static pressure signal. A counter-wheel reads out total compensated flow by using a pair of cylinders.

The integrating mechanism consists of two bakelite cylinders (Fig. 2), each with a raised cam surface. The cylinder to the right is the differential cylinder and is revolved once a minute by the motor drive. As the differential cylinder is revolved in a counterclockwise direction, the cam on its surface, acting through the stylus of the differential arm, forces the top of the rocker lever and scale to the front of the instrument. Since the rocker lever moves about a shaft as a center, outward movement of the upper portion of the rocker lever causes the horizontal portion of the rocker lever to be raised, engaging special ratchet gears which couple the differential cylinder with the pressure cylinder. When these gears are in mesh, the revolution of the differential cylinder will cause the pressure cylinder to revolve for the interval during which the stylus of the differential arm is on the raised portion of the differential cam. The amount that the pressure cylinder revolves depends on the length of the arc on the surface of the cam of the differential cylinder. The cam is of such shape that the length of arc corresponding to any reading is proportional to the reading on the scale, and therefore proportional to the square root of the differential.

When the pressure cylinder is revolved, the cam on its surface, acting through the stylus of the pressure arm, actuates the corresponding rocker lever and causes the ratchet gears to engage the lead gear of the counter gear train. The shape of the raised surface of the cam on the pressure cylinder is exactly the same as the raised surface of the cam on the differential cylinder. Therefore, the motion transmitted to the counter gear train is proportional to the product of the square root of the differential pressure and the square root of the absolute static pressure. With proper gearing the motion transmitted to the counter causes an indication directly equal to a summation of the chart extensions.

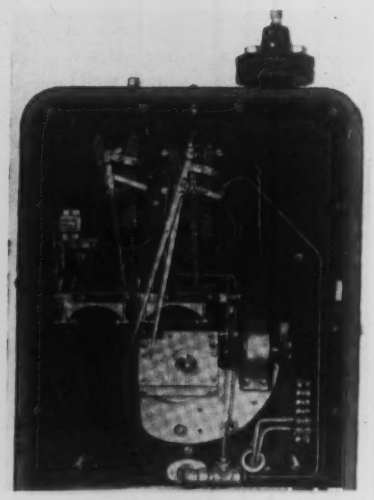


FIG. 1. AMERICAN METER flowmeter.

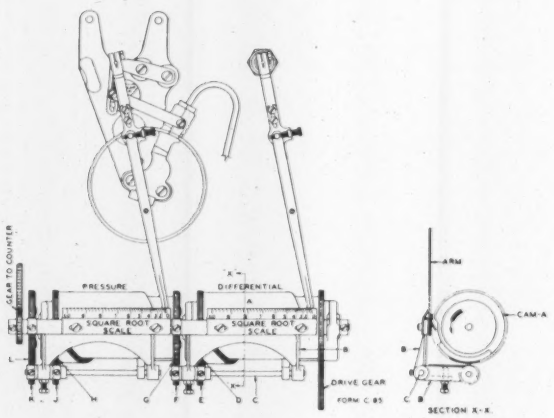


FIG. 2. INTEGRATING and compensating mechanism.

Bailey Meter Company

Bailey accomplishes pressure and temperature compensation either pneumatically or electrically.

Pneumatic System

The pneumatic system is shown in Fig. 3. As flow rate is proportional to the square root of the head across the orifice, the *flow transmitter* extracts the square root of the differential-pressure (ΔP) signal and develops a pneumatic signal that is proportional to flow rate directly.

The signal goes to a computing relay (Fig. 4) which also receives a pneumatic signal from a pressure transmitter located well upstream of the orifice.

As shown in Fig. 4, there are five bellows units in the computing relay. The temperature signal goes to the bellows on the back of the unit, which operates a characterized cam. Hence motion of the shaft on the cam follower is a signal proportional to the square root of the pressure (because pressure compensation requires a $P^{1/2}$ signal).

The signal from the flow transmitter goes to one of the large bellows in the relay unit, which positions a beam. The beam motion and the shaft motion are combined *mechanically* to operate one of the relays on the side, which develops a pneumatic signal proportional to the product of the flow and pressure signals. (The two unused bellows are for reversing, reset and other computing actions if desired.)

For temperature compensation, a second computing relay is used, which receives one pneumatic signal from the temperature transmitter and one from the first relay. Its output, a pneumatic signal compensated for both temperature and pressure, goes to a conventional receiver recorder or controller.

Electric System

The electric system (Fig. 5) uses three impedance bridges with movable-core transformers, and one Wheatstone bridge (Fig. 6). Unlike the pneumatic system, linear signals are used throughout to develop the product of pressure-differential times pressure over temperature ($\Delta P \times P/T$). The square root of this product is extracted in the receiver as the last step.

The basic flow signal (ΔP) is developed by the core of a movable-core transformer (MCT), which is positioned by a d-p bellows element connected to the orifice. Hence an electrical signal (e_1) proportional to the differential pressure appears across the potentiometer slidewire PSW.

If no compensation were required, this signal would go directly to amplifier 1, which also receives a signal (e_2) from the impedance bridge in the receiver. Any difference between these two signals causes the amplifier to drive the motor in the receiver until the core of the MCT at right is in such a position that $e_2 = e_1$. When this occurs the motor stops, and the core in the receiver has been made to follow the core in the d-p transmitter accurately. Note that e_2 would then equal the d-p signal.

For pressure compensation, the core of another MCT is positioned by the pressure to be compensated, usually through a Bourdon element. This transformer

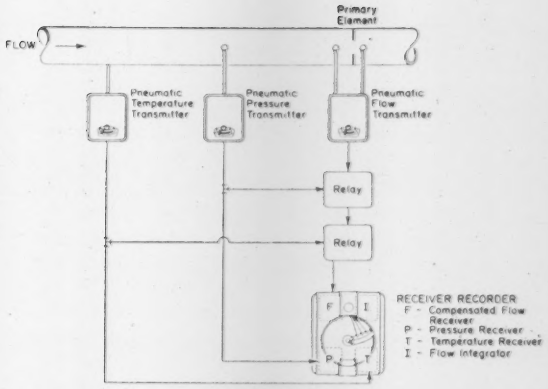


FIG. 3. BAILEY pneumatic system for pressure and temperature.

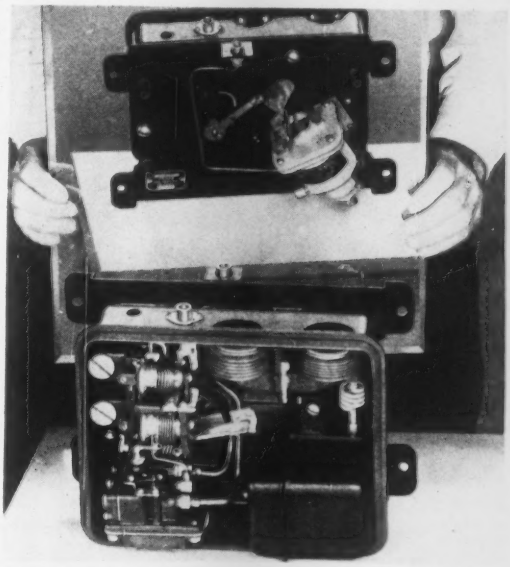


FIG. 4. BAILEY computing relay has function-generating cam on rear bellows unit.

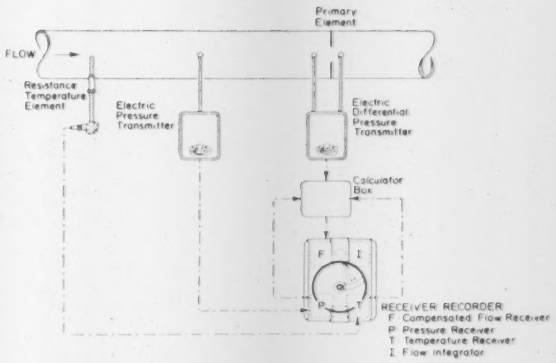


FIG. 5. BAILEY electric compensating system.

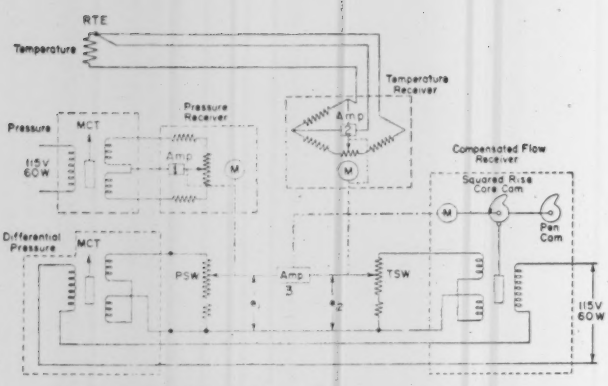


FIG. 6. SCHEMATIC of Bailey electric system.

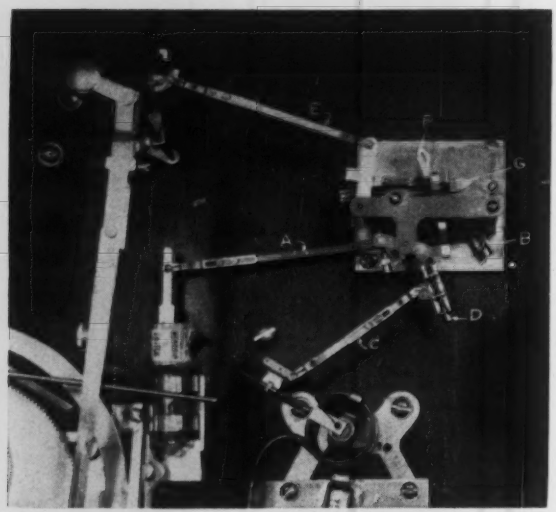
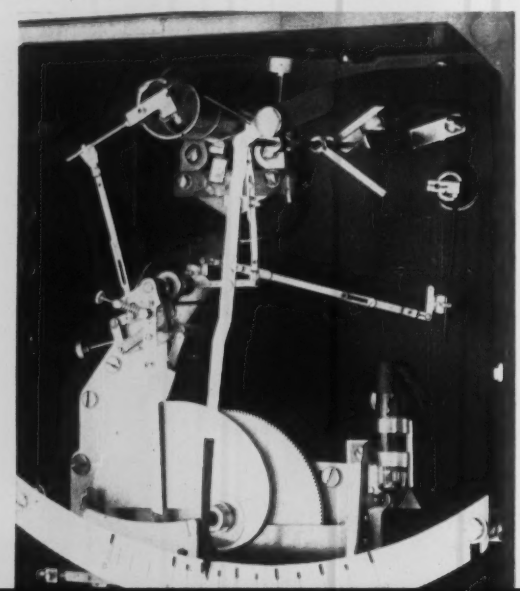


FIG. 7. Barton compensated flowmeter unit.

FIG. 8. BRISTOL linkage with static pressure correction introduced by helical element at top left. Cam can extract square root of head.



is in another impedance bridge whose amplifier (amplifier 2) positions a motor which (1) repositions the bridge slidewire to reduce its amplifier signal to zero and (2) also positions the tap on the PSW slidewire. Hence signal e_1 is now proportional to the product $\Delta P \times P$. If no temperature compensation were required, the signal e_2 would also be equal to this product of flow and pressure.

For temperature compensation, a resistance thermometer is used in a Wheatstone bridge circuit whose unbalance operates a motor to restore the balance, using amplifier 3 shown. This motor also positions the tap on the transmitting slidewire (TSW), so that the signal at the tap is now the product of the temperature signal and the bridge signal. The motor rotation in the receiver thus becomes equal to a function of ΔP, P and T as follows:

$$e_1 = (\Delta P)\,(P)$$
$$e_2 = (T) \times f\ (\text{core position})$$

As e_2 is made to equal e_1:

$f\ (\text{core position})\,(T) = (\Delta P)\,(P)$

Hence core position $= f(\Delta P \times P/T)$, as desired.

The motor is made to rotate an amount equal to the square root of this compensated signal by driving the core through a square-root-type cam.

The pen cam is simply a linear cam that transforms the rotation of the motor shaft into a proportional pen position so that the record is proportional to the square root of ΔP, compensated for both temperature and pressure.

In both the pneumatic or electric system a single recorder can display temperature, pressure, compensated flow, and totalized flow, if desired.

Barton

The Barton Model 243 pressure-compensated integrating flowmeter measures gas flow rate under conditions of constant specific gravity and essentially stable temperature. It compensates for variations in static pressure from 10% of the static-pressure element rating up to full static pressure.

The Model 243 meter transfers to the square-root extracting mechanism the product of the differential pressure and the absolute static pressure through a multiplying linkage. In Fig. 7 A is the link from the differential-pressure sensing element; B is the calibration adjustment to correct for variations in individual differential-pressure sensing elements. C is the input signal from the static-pressure spiral and D is the corresponding calibrating element for compensating for individual variations in such elements. E is the combined output, which represents the product of pressure times differential pressure; this (E) actuates both the recording pen and the square-root extracting mechanism. F is a supplementary differential-pressure indicating scale that gives the order of magnitude of the differential pressure being sent; G performs the same function for static pressure.

Typical factory calibration accuracy calls for $\pm 0.75\%$ when differential pressure is 10% of full scale and static pressure is 20% of full scale ($\pm 0.5\%$ at higher values).

Bristol

Bristol mechanical flowmeters (used with U-tube, bell-type, or bellows-type differential bodies) can be compensated for either pressure or temperature (but not both) by a mechanical linkage connected to the flow measuring pen. A static-pressure (or temperature) measuring element varies the linkage to effect the compensation. A helical element is used for temperature; either a helical or capsular element is used for pressure measurement (Fig. 8).

The Metameter system (Fig. 9) comprises a receiver and transmitter. The transmitter is a rotating cam which engages the pointer, making a mercury switch close for an interval that is proportional to the pointer position. Thus the variable (flow) is converted to an electrical impulse whose duration (3-12 seconds, or 1-4 seconds, depending on model) is proportional to the variable measured. The cam can be shaped so that it extracts the square root while it is developing the pulse signal for transmission.

In the Metameter receiver, a solenoid is energized for an interval equal to the duration of the pulse, and a differential gear arrangement positions a pen in proportion to the duration of the incoming pulse.

For electrical pressure compensation, a slidewire is added to the receiver mechanism (Fig. 9). The wiper is positioned by the receiver and thus gives a signal equal to uncompensated flow.

A second Metameter transmitter is used to develop a signal proportional to the line pressure. The wiper of a second receiver is positioned by this pressure signal.

The tap of the flow slidewire is connected to the pressure slidewire; this multiplies the two signals resulting in a compensated flow signal at the tap of the second slidewire. This emf signal is then sent to a potentiometer-type Dynamaster instrument for recording or control.

A third set of Metameter stations can be used for temperature compensation.

Bristol's new Dyna-Servo computing telemetering system (Fig. 10) includes a flow transducer, the new Dyna-Servo pressure transducer, a new Dynamaster totalizing computing and transmitting instrument, and Bristol's pulse-width to pulse-count transducer-type Integrator with counters.

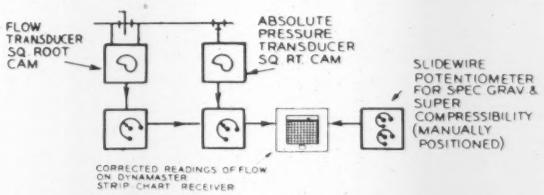

FLOW TRANSDUCER SQ. ROOT CAM
ABSOLUTE PRESSURE TRANSDUCER SQ. RT. CAM
SLIDEWIRE POTENTIOMETER FOR SPEC GRAV & SUPER COMPRESSIBILITY (MANUALLY POSITIONED)
CORRECTED READINGS OF FLOW ON DYNAMASTER STRIP CHART RECEIVER

FIG. 9. BRISTOL Metameter system with slidewires added to introduce compensation.

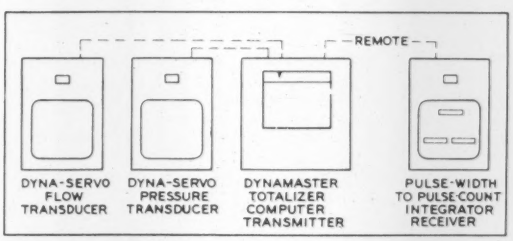


FIG. 10. BRISTOL'S new Dyna-Servo computing telemetering system.

The Dyna-Servo transducer is a null-balance instrument. A signal determined by the measured variable (temperature, flow, pressure) is fed from the error-detector to an amplifier. The amplified signal is fed to a servo-motor which positions a servo-shaft for operating a retransmitting slidewire, encoder, alarms, deviation contacts, etc. The feedback cam on the servo shaft can be contoured to provide exponential values.

The Dynamaster totalizing-computing instrument includes a Metameter transmitter and has manual adjustments for specific gravity and supercompressibility

At the receiving station the Integrator receives the output signal from the transmitter in the Dynamaster and converts the pulse-width signal to pulse-count. A cumulative counter and two counters for hourly totals indicate corrected, integrated flow.

Foxboro

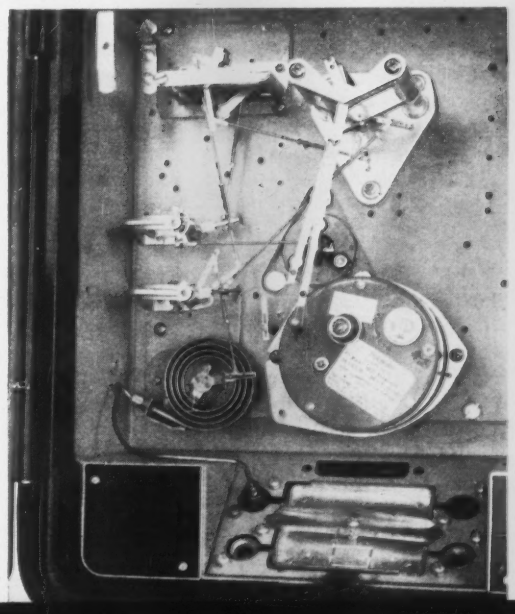
Foxboro offers both mechanical and electrical systems for pressure and temperature compensation of differential-pressure flowmetering signals.

Mechanical Systems

Two mechanical systems are offered, one is the Static Pressure Compensator (Fig. 11); the other is the Air Weight Compensator Mechanism (Fig. 12). Both are pressure compensating mechanisms, and the Air Weight bellows (PH 7167) has built-in temperature compensation.

The *Static Pressure Compensator* PH 8408 (Fig. 11) uses a pressure element and a linkage system to displace the center of rotation of the mechanical lever that drives the recording pen, effectively multiplying the two signals (head and pressure). When a square root chart is used, the flow signal is a linear head signal and the pressure signal is also a linear signal;

FIG. 11. FOXBORO static pressure compensator.



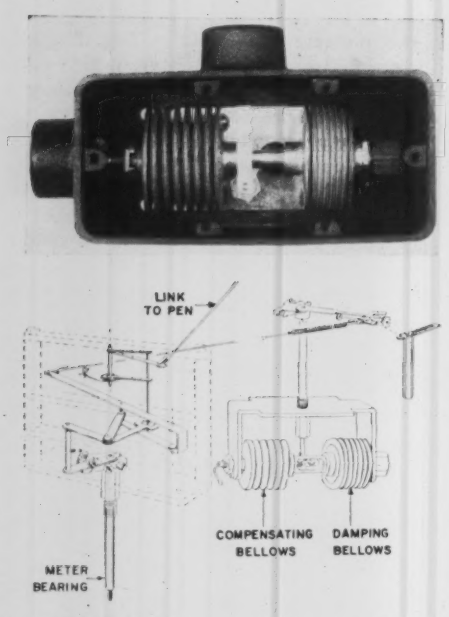


FIG. 12. FOXBORO air weight compensator mechanism is sensitive to temperature and pressure.

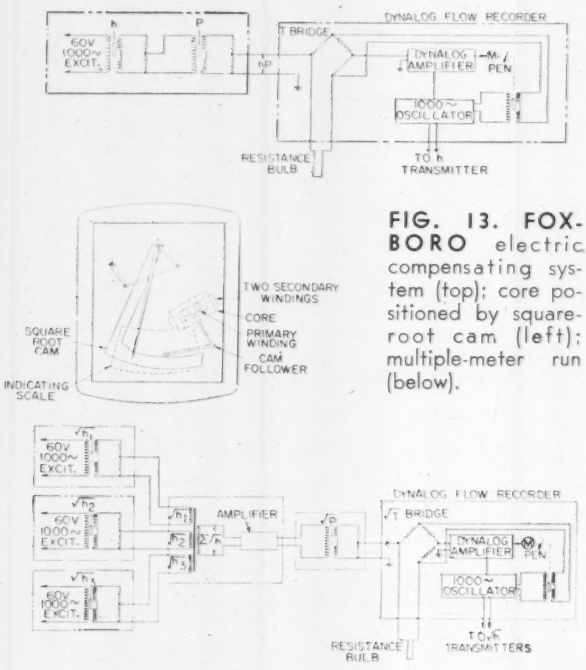


FIG. 13. FOXBORO electric compensating system (top); core positioned by square-root cam (left); multiple-meter run (below).

the square root is extracted by the chart. When a square root flow element (shaped range chamber) is used, the compensator mechanism is adjusted so that it extracts the square root of the pressure signal.

The *Air Weight Compensator Mechanism* Fig. A1863 (Fig. 12) also changes the center of rotation of a lever that drives a recording pen, but the sensitive element used is responsive to changes in both pressure and temperature. This is done by using a sealed bellows containing low-pressure inert gas, and by making the process gases (usually air) flow through the compensator housing and around the bellows. Thus, increasing pressure compresses the bellows; increasing temperature expands the gas inside the bellows, expanding it. The resulting bellows motion is transmitted to the compensating mechanism through a pressure-tight bearing. The compensator compensates for changes in process air pressure up to 6 psi; and for temperature changes up to 250°F. The unit is widely used in measuring air flow, as in cupolas in iron foundries, open hearths, furnaces, etc.

An unsealed bellows in the unit acts as a dampener to counteract momentary pulsations in the flow line.

Electric Compensation

Foxboro electric compensating systems are based on the use of Foxboro Dynaformer transducers, whose cores are positioned by the flow and pressure pickups (Fig. 13). By energizing the primary of the static pressure Dynaformer unit with the signal from the differential pressure Dynaformer unit, a signal proportional to the product hP is developed.

Although another Dynaformer transmitter could be used for temperature compensation, best practice is to use a resistance thermometer in a bridge in series with the hP signal. The bridge output then becomes proportional to hP/T when the bridge is balanced by a third Dynaformer unit as shown.

If the Dynaformer core is positioned linearly, the result is a record proportional to hP/T. The square root for flow then can be extracted by using a square root chart.

The Dynaformer unit also can be positioned via a square-root cam to extract the square root. Here the $\sqrt{h}$ is extracted in the first Dynaformer unit; the $\sqrt{P}$ is extracted in the second, whose output is $\sqrt{hP}$. The signal goes into the bridge, one leg of which is a resistance thermometer, as shown.

Dynaformer units make possible simple addition of signals for multiple meter runs as shown in Fig. 13.

Hagan

The Hagan Ring Balance flowmeter is a mercury or oil-filled instrument that operates on the torque principle. The torque is developed by the differential pressure acting across a partition in a hollow ring (Fig. 14). The sealing fluid is mercury or oil, depending on the range desired. A feature of the basic principle is that, because it is a torque device, the instrument can be calibrated by weights acting on a radius arm.

Rotation of the ring element is opposed by a nonlinear spring and resistance system which extracts the square root of the motion. A cam and follower positions the pen, which thus records the square root of the differential pressure (flow).

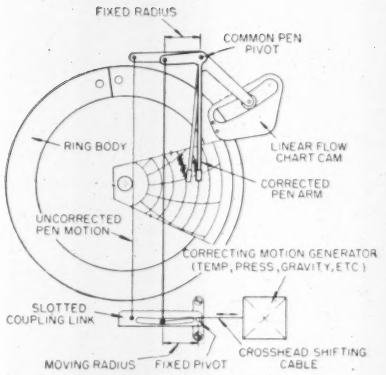


FIG. 14. HAGAN flowmeter with mechanical compensation linkage.

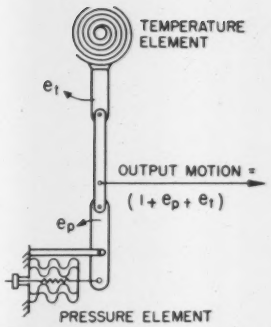


FIG. 15. HAGAN summing linkage.

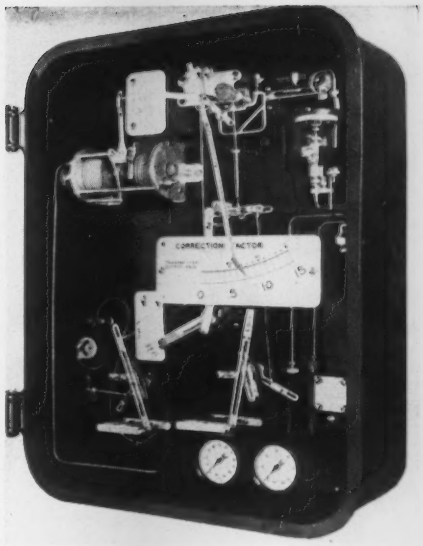


FIG. 16. HAGAN wide-range pressure and temperature correction-signal generator.

Single-element (Pressure or Temperature) Compensation

The uncorrected pen arm responds to the motion of the ring body, caused by changes in the differential pressure across the orifice. This pen also is connected to one end of a slotted coupling link or compensating frame (Fig. 14); the other end of the link is pivoted. Movement of the uncorrected pen, therefore, causes the coupling link to rotate about the fixed pivot.

The corrected pen arm, which moves on the same pen pivot as the uncorrected pen, is linked to a cross head which rides in the slot of the compensating-frame coupling link. Thus the motion of the corrected pen is the motion of the uncorrected pen times the motion of the correcting motion generator.

The correcting variable (temperature or pressure) is transmitted to the *correcting motion generator* (Fig. 14), which contains a bellows pressure element or a mercury-filled temperature spiral. This assembly positions the crosshead in the slot of the coupling link by use of linkages which extract the square root (if desired) so that the final corrected pen motion is $\sqrt{P\Delta p}$, as desired.

Although Fig. 14 shows a pen for uncorrected flow and another for compensated flow, usual practice is to record only *compensated flow*, using the uncompensated indicator for calibration and adjustment purposes. (Lack of true indication of uncompensated flow can make calibration and adjustment of a flowmeter a tedious and difficult procedure.)

Narrow-Range Pressure and Temperature Compensation

Where pressure and temperature variations are within certain limits, the corrections can be combined by a simple summation linkage using the following approximation. Let:

e_p = % error from pressure/100%

e_t = % error from temperature/100%

f_p = pressure correction factor = $1 + e_p$

f_t = temperature correction factor = $1 + e_t$

The product of the pressure correction factor times the temperature correction factor is:

$$f_p f_t = \text{total correction factor} = (1 + e_p)(1 + e_t)$$
$$= 1 + e_p + e_t + e_p e_t$$

If the product of e_p times e_t can be disregarded, the combined correction factor is:

$$1 + e_p + e_t$$

The product e_p times e_t can be considered negligible as long as both e_p and e_t are less than 0.1—which is true if the correction factor for pressure or temperature is less than ±10%. Within these limits the pressure-correction factor times the temperature-correction factor can be approximated by the sum of the departures, plus unity.

A simple summation linkage is shown in Fig. 15. This system can be applied generally when the pressure variation does not exceed 50% of the normal operating absolute pressure, and when the temperature variation does not exceed 20% of the normal operating temperature.

Wide-Range Pressure and Temperature Compensation

The instrument shown in Fig. 16 is a device which multiplies a pressure-compensation signal with a temperature-compensation signal (using the multiplying linkage shown in Fig. 14), developing a pneumatic signal equal to the final signal. This pneumatic signal then goes to the correcting motion generator in Fig. 14, positioning the link in the slotted crosshead so that the pen signal is compensated flow, as described previously. The square root of the pressure and temperature signals is extracted on each of the inputs before the multiplication process. A "radial coupling" is used to perform this characterization.

OUTPUT ZERO SIGNAL LEVEL

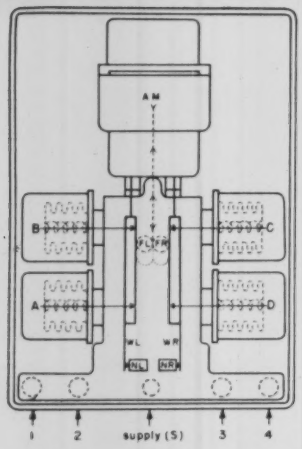


FIG. 17. **SORTEBERG** force bridge.

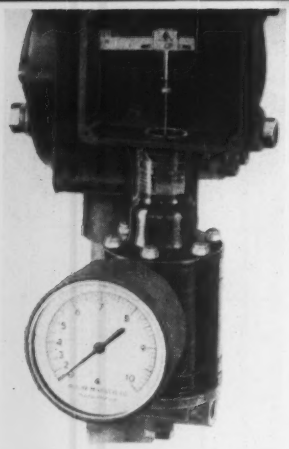


FIG. 19. **MOORE** motion transmitter.

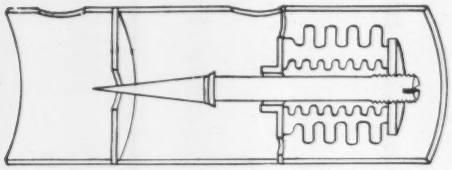


FIG. 20. **NIL** gas flowmeter is compensated for pressure and temperature.

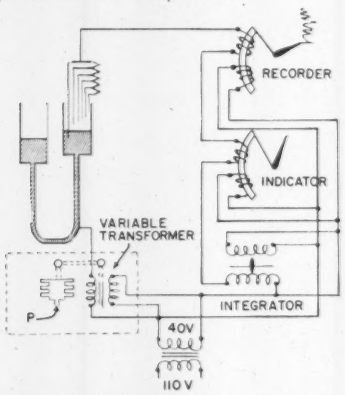


FIG. 21. **REPUBLIC** electric flowmeter with pressure compensation.

Minneapolis-Honeywell

The Industrial Division of M-H offers both a pneumatic technique and an electrical technique for compensation. The pneumatic is based on the *Sorteberg force bridge* (Fig. 17), which consists of two parallel weigh beams, each of which operates a nozzle-flapper unit (NL and NR). Four bellows units exert forces at the ends of the weighbeams, whose fulcrum rollers (FL and FR) are moveable. The fulcrum point is controlled by the left nozzle (NL) via an air motor; the output signal is taken from the bellows chamber connected to the right nozzle (NR.)

When the system is in equilibrium, the moments of forces around the fulcrum causes the following to be true:

$$A \times C = D \times B$$

Thus, if the temperature signal is a pneumatic signal connected to chamber A, the pressure signal to chamber B, the flow signal to chamber D, and the output is taken from chamber C, then:

$$C \times T = P \times \text{Flow}$$

$C = \text{Flow} \times P/T$, which is the desired compensated signal.

For square-root extraction, a square-root chart can be used or, if a square-root transmitter is used for the flow signal, the output of the relay is $P/T \times \sqrt{h}$, which is a first approximation to the desired signal ($\sqrt{hP/T}$).

Electric compensation technique is based on the new gas-flow computer (Fig. 18), a device that receives electric signals proportional to h, P, T and develops an emf signal equal to hP/T. This signal then has its square root extracted in an "Electronik" recorder.

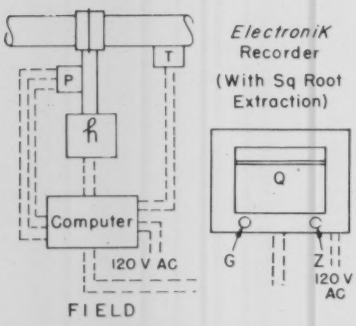


FIG. 18. M-H gas-flow computers.

Moore Products

The Moore H/P Differential-Pressure Transmitter uses a Barton Flowmeter as the measuring element for a Moore Motion Transmitter (Fig. 19), which develops a pneumatic signal. A Sorteberg computing relay is then used for applying pressure and temperature compensation pneumatically.

National Instrument Laboratories

The NIL gas flowmeter (Fig. 20) automatically compensates for pressure and temperature to give mass flow. It is basically an orifice with built-in pressure and temperature compensation.

The primary element is a variable orifice in which the area of the orifice is controlled by a bellows assembly sensitive to line fluid pressure and temperature. A shaped plug attached to the bellows assembly extends into the orifice. The bellows assembly contains a gas permanently sealed in. An increase in line pressure compresses the bellows so that pressure inside the bellows is essentially the same as line pressure. This compression of the bellows moves the plug farther into the orifice, decreasing the effective area. Likewise, a decrease in the temperature of the gas flowing in the line decreases the temperature of the sealed-in gas in the bellows assembly. This causes a contraction of the bellows and again decreases the orifice area. The plug is shaped so that the effective area of the annular orifice produced is inversely proportional to the square root of P/T—the compensation required to make the square root of the differential pressure proportional to the mass flow rate.

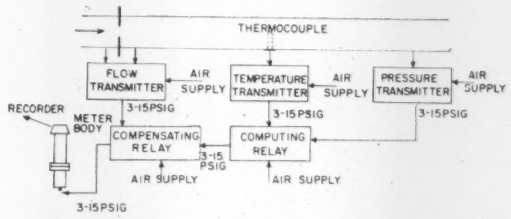


FIG. 22. REPUBLIC pneumatic-electric flowmeter compensated for both pressure and temperature.

Republic Flow Meters Co.

The Republic flowmeter (Fig. 21) is basically a mercury manometer in which the mercury level makes contact with a series of resistance elements, thus translating the mercury level directly into a resistance change. In the "electrically operated flowmeter" the mercury U tube is connected directly to the orifice-plate taps; in the "pneumatic-electric" flowmeters, a differential transmitter at the orifice plate develops a pneumatic signal proportional to flow, which is then sent to the flowmeter.

Pressure compensation of the electrically operated flowmeter is shown in Fig. 21. The meter body is connected directly to the orifice connections. Its resistance element is in series with the secondary of the variable transformer, thereby regulating the current that flows to the coils in the moving-iron-type indicator.

The variable transformer comprises a rotor connected in series with the flowmeter circuit and a stator connected in parallel across the transformer on the panel. A pointer turning around a dial graduated in degrees shows the position of the rotor. When the pointer is at 90° the rotor is in the neutral position.

For pressure compensation, the rotor shaft is turned by the action of a pressure bellows which moves a rod against a calibrated spring. The motion of the rod is transmitted to the rotor shaft by a lever, steel ribbon and a cam. The cam gives the proper rotor rotation to correct the meter readings to the square root of the ratio of the actual to the design pressure.

Fig. 22 shows how the pneumatic-electric flowmeter is compensated for both pressure and temperature. Here the flow, pressure and the temperature signals (the latter are taken downstream of the orifice) are all first converted into proportional pneumatic signals. The signals from these transmitters are fed into a remote-set computing relay. This relay has a flapper-nozzle unit (Fig. 23) whose pneumatic gain is affected by the angle of the flapper, which is in turn controlled by the two incoming signals. One of the inputs moves a piston and cam, which extracts the square root of the signal.

In the application shown in Fig. 22, the pressure signal is divided by the temperature signal in the first remote-set ratio relay, and the output loads a second remote-set ratio relay. In this second relay the steam flow signal from the flow transmitter is multiplied by the signal from the first relay to develop a pneumatic signal that is the compensated flow signal. This signal operates the electric flowmeter, as shown.

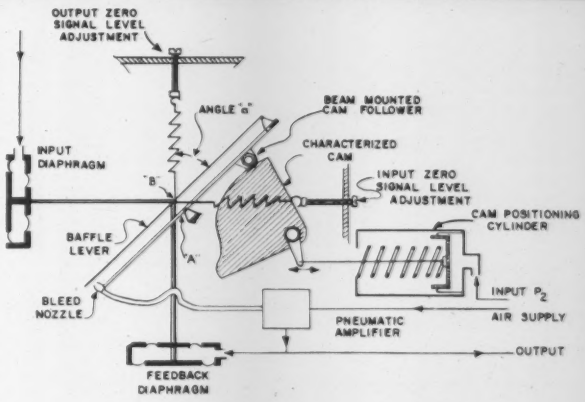


FIG. 23. REPUBLIC remote-set relay.

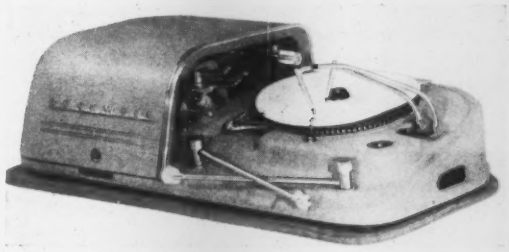


FIG. 24. ROCKWELL integrator.

Rockwell Manufacturing Co

The Rockwell integrator (Fig. 24) computes and multiplies the instantaneous square root values of the product of two variables—when pressure compensation is required, the signals are differential and absolute static pressure. Compared to using radical or square root planimeters, the integrator cuts time in half. It is conservatively 7 to 8 times faster than the manual observation method of obtaining the extension. It is accurate to within 0.5% through the ranges and types of charts which it was designed to integrate.

The integrator pens superimpose ink lines on the original chart record, making it possible to check the work of the operator at a glance. An operator can calculate over 300 average charts daily, rendering the whole chart calculation complete through grand total extension.

The Integrator uses the square-root-cam principle. The top mechanism consists of three discs of plates, the smallest being the time plate, the intermediate being the pressure plate and the largest being the chart plate.

The time and chart plates are geared together in constant ratio and driven by a variable speed A. C. or D. C. motor. The pressure plate is positioned above the time plate. Between these plates contacting them is a steel disc roller, called the pressure roller, which can be moved across the face of the time plate from the center to the right outer edge. By moving the position of the pressure roller, the speed ratio between the time plate and the pressure plate can be changed. A second roller, the differential roller, can be moved across the top surface of the pressure plate. Connected to this roller is a dial counter. The resultants obtained from the counter depend on the frictional speed ratio changes, which are governed by the position of the rollers moving across the plates.

Effective Selection of

WILFRED H. HOWE
The Foxboro Company

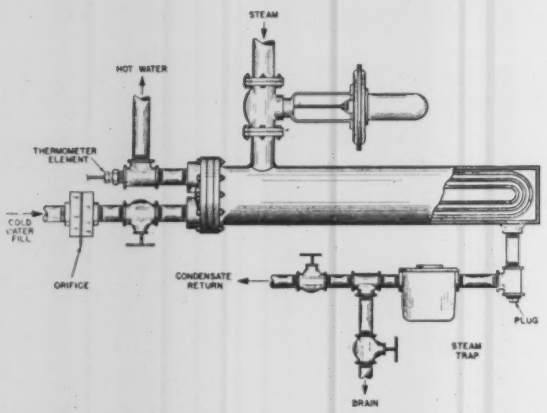
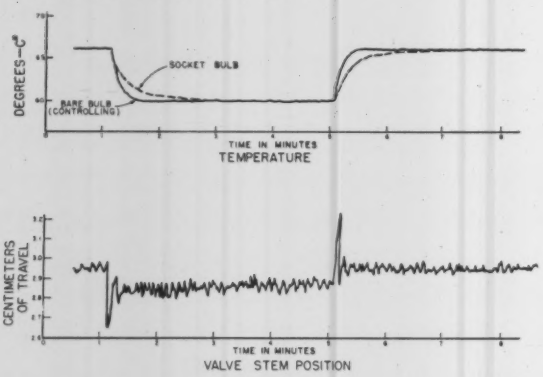


FIG. 1. HEAT EXCHANGER. Temperature of fluid leaving exchanger is measured by resistance thermometer in a well, and by a second high-speed resistance thermometer directly in stream.

FIG. 2. RESPONSE OF SYSTEM to 6° change in set point, using the high-speed measurement. Top shows bulb in socket, compared with high-response element. Bottom shows valve response.



MEASUREMENT is an integral part of automation. Indeed, automation could be defined on the basis that true automation includes measurement and response to measurement as an integral part of the system.

The continuous processing industries such as petroleum refining, chemical processing, electric-power generation, paper making, food processing and nuclear-energy applications, are excellent examples of highly developed automation, and of the application of measurement as an integral part of the production process. In this paper the examples of measurement and its application will be drawn from this field of continuous flow processing. However, the salient points are applicable to the whole field of automation.

Presented at the Fourth International Automation Congress, June 10, 1958.

What is the True Significance of the Measurement?

Two factors of major importance affect the significance of a measurement. First, how well does the measurement represent the characteristic or condition supposedly being measured? Second, what does this measurement mean with regard to the actual process operation? The measurement obtained can be significant only to the extent that the primary element is exposed to a condition or characteristic which is (1) truly representative and accurately measured, and (2) of significance to the process.

For example, in a simple temperature measurement the value being measured is the temperature of the *sensitive portion* of the primary measuring element—the bimetal strip or the fluid filling or the resistance wire or the thermocouple junction, depending on the type of instrument used.

How well the measurement represents the *true temperature* of the process is affected by a number of factors. In the first place there is the question as to whether there exists one measurable temperature which is truly representative. There is no problem in a well-stirred water bath, but in many operations, stratification, dead pockets, hot spots and the like may result in important temperature differences between different points of measurement. The desirable procedure is to eliminate these differences. When this is not practical, two things are essential. First, it is necessary to select the best available measurement point or points. Second, and often neglected, it is necessary when using the measurement to recognize that it is less than truly representative.

Instrument Accuracy

With the primary measuring element suitably mounted with respect to the process, the next point is instrument accuracy. How well does the instrument output correspond to the primary element? In our

Measurements for Process Control

With the wealth of measurements available, selection constitutes a major engineering problem. Selection should be on the basis of (1) What is the true significance of the measurement? (2) What will be accomplished as a result of the measurement? (3) What will it cost to obtain the measurement?

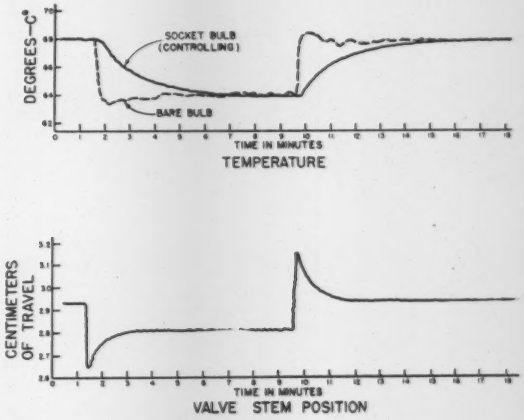
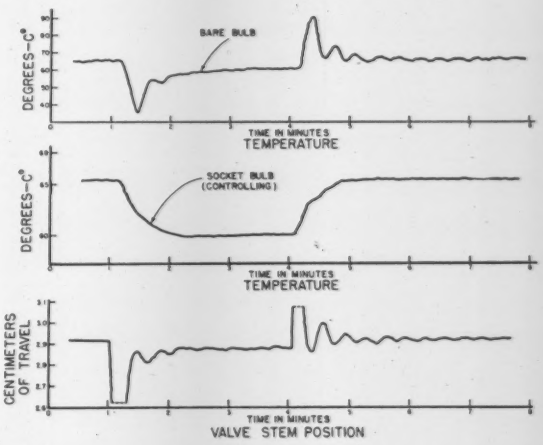


FIG. 3. RESULTS OBTAINED when controller is adjusted properly for use with low-speed thermometer.

FIG. 4. CONTROL RESPONSE using low-speed measurement systems and controller improperly adjusted for lag. Actual temperature (top) varies nearly 70° although bulb in socket shows only 6° change.



thermometer example, how close is the indicated temperature to the actual temperature of the primary element? This question of required accuracy is often a major factor in selection.

Higher accuracy is generally available at added expense. Statements of accuracy and performance furnished by instrument manufacturers are a reliable guide. It is usually good judgment to pick out the better rather than the cheaper measurement. On the other hand, unrealistic specifications calling for improbable and often unnecessary performance can lead not only to excessive first cost but may result in the selection of an unnecessarily complicated measurement which requires a large amount of maintenance effort.

Accuracy is almost invariably specified on a steady-state basis. Dynamic performance—that is, how the measurement output responds on a time basis to changes in the value being measured—is only beginning to receive the attention it so richly deserves. For example, in industrial practice the thermometer primary element is almost invariably mounted in a thermal well to protect it from the process fluid and to make possible withdrawing, checking and replacing the element without interrupting process operation. The thermal well at best introduces a considerable time lag in the response of the measurement. When the measurement is used for control, this lag can have rather startling effects, as illustrated in Figs. 1, 2, 3 and 4.

Effect of Instrument Lag on Dynamic Response

These illustrations refer to a commercial heat exchanger set up under laboratory conditions. Fig. 1 shows the general setup. Temperature of the fluid flowing from the heat exchanger is the measured variable. Two separate measuring systems are used—one a conventional resistance thermometer mounted in a standard socket immersed in the line, the other a special high-speed resistance thermometer directly immersed in the stream to give faster response to stream temperature.

The curves in Fig. 2 show the results when control was operated from the high-speed measurement. In the upper graph the solid line is the temperature recorded from the high-speed thermal system; the dotted line shows the measurement from the conventional socket-mounted thermal system. All curves show the effect when the set point was lowered and raised 6°C. The lower graph shows the valve response, with almost immediate response and only slight overshoot.

Fig. 3 shows the results obtained with the controller suitably adjusted for operation from the measurement provided by the low-speed socket-mounted bulb. The time scale is double that of the previous curve. Comparing Figures 2 and 3, note that with the control operated from the slow measurement and with suitable controller settings, the control of water temperature (as measured by the fast thermometer) was al-

most as good as the control obtained from the high-speed thermal system.

Measurement Lag is Dangerous

However, Fig. 4 shows what can happen with the controller operating from a low-speed thermal measurement if the lag of the measuring system is disregarded. The middle curve shows the response to the control action as measured by the low-speed system. This measurement shows only a 6° change in temperature. However, taking the measurement from the fast system as representing the true temperature of the process fluid, actual temperature fluctuated widely, as shown in the upper curve. Note that the temperature scale in this upper curve has to be compressed to get the curve on scale. A change in temperature set point of about 6° caused an initial swing of more than 30° in true temperature. The lower curve showing the valve operation indicates the fact that the valve excursions also were excessive.

This example is typical of measurement dynamics and their effects. If the lags can be eliminated, better control with less critical adjustment and wider dynamic range can be obtained. However, if lags exist in the measurement, either inherently or resulting from an application practice (such as thermometer wells), it is almost always possible to make allowance to take care of this without serious effect on process operation. It is important to recognize and make allowance for the dynamic as well as the static characteristics of measurement if optimum results are to be obtained.

Lag in measurement is particularly dangerous. If overshoot or instability results from process lag, this shows up normally in the measured record of performance. However, there is usually no direct indication of instability which results from measurement lag. Usually there is no high-speed measurement available for comparison, as in the illustrations given. The measurement can appear smooth and stable—but variations which can adversely affect product quality or processing operation can exist without showing up in the measurement output.

Temperature has been used as a simple example. In more complex measurements the problems are often more difficult. Typically, analytical devices which measure composition or similar characteristic of a flowing stream usually depend on sampling. This in itself accentuates all of the problems discussed. Regardless of the simplicity or complexity of the measurement, it is essential to understand the problems and limitations, to make every reasonable effort to minimize these limitations, and to recognize the resultant effects on the validity and significance of the measurement.

Significance of the Measurement on the Process

The second phase of significance of measurement is concerned with the actual meaning of the specific measurement with respect to the process operation on which it is applied. What is to be accomplished as a result of measurement? It is surprising how often insufficient attention is paid to true significance, resulting in applications which fall short of what is desired. Three examples will be stated to illustrate the variety of significance which attaches to a specific measurement in differing applications.

Steam Temperature as a Measure of Quality

A simple case—temperature measurement of the steam from a steam boiler is a direct quality measurement. Knowing the characteristics of the process fluid (dry steam with some superheat), temperature, pressure, and the pressure drop across an orifice or flow nozzle as a primary measurement for flow, the characteristics of the steam output are completely defined. The temperature is measured directly. The measurement is commonly recorded and also applied to a control system to maintain the temperature at a desired value for the particular operating conditions. Note that the temperature is of interest in itself. Superheat, which is in general of greater significance, is derived from a temperature measurement *and* a pressure measurement. Flow is computed from pressure drop across the orifice, corrected for both temperature and pressure.

Steam Condensing Temperature as a Measure of Paper Moisture Content

A second example of the application of temperature lies in the measurement of condensing temperature of steam used for the drying of paper on a paper machine. Here the objective is to dry the paper so that the moisture content of the final product is at the desired level. Temperature is adjusted in accordance with some independent determination of moisture content. In this operation, steam condensing temperature is not a measure of the paper moisture content itself but, rather, of the processing condition inferentially related to product quality. Constancy and repeatability of the measurement are of importance—but absolute value has relatively little significance. This type of measurement of process condition is common.

Any change in temperature produces a corresponding predictable change in moisture content. Since steam temperature measurement is simple, reliable and relatively inexpensive, it is used as a basis for moisture content control. In usual operation, temperature is adjusted when a change in moisture content is desired. However, moisture content of the sheet depends

the Measurement?"

not only on the temperature but also on a number of other variables, including freeness of the stock supplied to the machine, condition of the press felts, and other variables equally difficult to measure. Hence measurement and control of temperature of the dryers is useful but not in itself *sufficient* to produce the desired product quality. This is typical of inferential measurements where a process condition instead of the product characteristic is measured.

The determination of the actual sheet moisture content may take a variety of forms. Typically, the operator may simply judge moisture content by the "feel" of the sheet. On the other hand, moisture content may be continuously monitored by a measurement of dielectric constant, which in turn is calibrated against sample gravimetric moisture determinations.

Temperature in the Measurement of Gas Flow

A third type of application of temperature measurement is in the measurement of gas flow. In gas production and distribution, measurement is in terms of standard cubic feet. Considering the fact that major gas measuring stations can handle hundreds of millions of cubic feet per day, it is obviously impractical to get all of this gas to a condition of standard temperature and atmospheric pressure and then proceed with a volumetric measurement. The American Gas Association Report No. 3, the current standard, expresses total gas flow as the result of a series of computations. There are a set of empirical coefficients, the primary variable being differential pressure across the orifice; then corrections are made for static pressure, temperature, specific gravity, supercompressibility, etc. The American Gas Association has devoted a great deal of work to determining as closely as possible all of the variables which affect the measurement. With an installation made in accordance with recommendations, and with suitable measurement of the variables, the total flow of gas can be determined to a high degree of accuracy.

Here the temperature itself is of no interest whatever. However, since a 10°F change in temperature results in a change in density of about 2%, which in turn has a 1% effect on the total flow measurement, it becomes important that temperature be accurately known.

The contrast between gas measurement and paper moisture should be noted. In each, a number of variables affect the final result. In gas measurement the significant variables are measurable; as a result the flow in terms of standard cubic feet can be determined by computation. In contrast, in paper making there is an equal or greater number of variables affecting moisture content, but temperature is about the only one that can be readily measured. It is also the manipulated variable whereby the final product quality is maintained at a desired value. Since many of the other variables which affect moisture content are not measurable, we can not determine the actual value of moisture content. However, temperature measurement serves a useful purpose in the paper drying operation.

The same general reasoning applies to other measurements. The problems involved in some of the more complex analytical determinations require a considerably more detailed study to fully appreciate the significance of some of the measurements. However, the same general principles apply. The importance lies in the fact that, regardless of the measurement, significance with regard to the operation should be thoroughly understood as a basis for the selection, the application, and the interpretation of the resulting measurement values.

What is to be Accomplished as a result of the Measurement?

For any specific measurement, the answer to this question is implicit in the basic significance of the measurement. When the true meaning of measurement is fully understood, there is understanding of what its application can accomplish. Going back to examples previously cited, the measurement of temperature of steam coming from a boiler can provide a variety of results. The temperature itself is a matter of considerable interest and can be used directly as the basis of automatic control. The temperature in conjunction with the pressure and differential pressure provide complete information with regard to quality and quantity of steam produced. This combined measurement can be used directly both for control purposes and also as a basis of plant balance, efficiency, and other determinations.

In contrast, the measurement of the temperature of natural gas in distribution lines has a single purpose, the determination of a correction factor affecting the measurement of the total flow in scfm. There is no direct interest in the actual value of the temperature; furthermore, this value is almost never used as a basis of control or other manipulation.

The basic objective of industrial measurement is to contribute to plant operation for maximum profit considered on an over-all basis. Many measurements obviously are profitable. In other cases a balanced judgment is called for between what can be accomplished as a result of a particular measurement (in terms of improved quality, increased productivity, decreased manufacturing expense and so on) against what is involved over-all in providing the particular measurement. The factor of judgment is often particularly important where the choice lies between a simple,

"Instruments Reduce Plant Investment"

easily available measurement of a quantity related only indirectly to the desired value versus a much more complicated and expensive measurement with a much more direct correlation to the value desired.

The usual considerations of better quality, greater quantity, and decreased labor are obvious and well recognized. Safety in many instances is a direct function of measurement—all the way from over-temperature indication of an airplane engine to the automatic "scram" of a nuclear reactor when the period becomes dangerously short. The use of measurement as the base of cost accounting and material and thermal balances is equally apparent.

Instruments Can Reduce Plant Investment

In most cases, instruments are considered as an addition to the producing plant. Somewhat less obvious is the case where measurements may be a major factor in reducing rather than increasing the over-all plant investment. Typically, in petroleum production, there is a major movement afoot to substitute automatic custody transfer for the present manual gauging operation on the producing leaseholds. This involves a major upheaval including the necessity of new permittive legislation. There is a considerable amount of not inexpensive measuring equipment required for each lease. However, the saving in the cost of tankage which could be effected by use of automatic custody transfer could result in a considerably lower total cost per leasehold. This is entirely aside from savings from labor and improved accuracy. This whole matter hinges directly on the question of reliability of the automatic measurements. There appears to be a strong presumption that modern measurement devices can be designed to produce more reliable and more accurate measurement than the gauge stick and manual sampling and testing procedures now in use.

Process Optimalization

Even more spectacular is the application of measurement to direct optimalization of processing operations. At least one large petroleum corporation is applying an on-line closed-loop digital-computer control to a standard refinery operation. The essential characteristics of the process itself are measured, computed and stored in the computer memory. Measurements of variables in the process are continually measured and fed into the computer. The computer combines this information at a high rate of speed and automatically adjusts the varying processing conditions in a manner directly calculated to produce the most profitable operation.

The direct approach to the objective of operation for maximum profit opens up exciting possibilities. There are the usual practical problems hinging to a considerable extent on whether the necessary measurements can be made available with sufficient accuracy and reliability. There is the broader question as to the specific approach most suitable for obtaining this optimum operation. The important point is that work is being done and real progress is being made in this direction.

Measurements are presently applied to provide a vast and vital range of information which makes possible modern automation. We can look forward with confidence to measurement applied directly to the objective of maximum profit. In our free world, where the basic force of natural selection operates through the profit motive, maximum profit is the final answer to the question—"What is to be accomplished as a result of measurement?"

What is Involved in Obtaining this Measurement?

This brings us to the last and final phase—the everlasting dollar sign. We are rapidly approaching the situation where almost any measurement is obtainable at a price. There are exceptions; quantitative measurements for flavor are still in the future. And there are still many other values which, for a combination of economic and technological reasons, are not measured continuously under plant operating conditions. Usually, however, it is simply a matter of dollars. If the economic value of a particular continuous plant stream measurement is great enough, nearly anything can be accomplished if the urgency is sufficient and the financing is adequate.

In the mundane field of normal plant operation, the objective always comes back to maximum profit. Overall cost must be reckoned with. The purchase price of equipment for any particular measurement is easily established. Necessary accessories, installation costs, etc., usually can be estimated with reasonable accuracy. Operation costs are less readily defined in advance. And the factor of reliability as it affects overall cost of operation must be seriously considered.

The question of what is involved in obtaining the measurement might be well broadened to include the question of what is involved when and if the measurement is not obtained. Interruption, even for a short time, of vital measurements on a critical process may necessitate complete shutdown, with a cost which may be several times the cost of the actual measuring equipment involved. Present techniques of operation on large nuclear reactors are a notable example of this.

To summarize, the first costs are definite. Operating costs, which in the long run may far exceed the initial price, are a matter of sound engineering judgement based on experience and on records of previous performance. Complete performance records, essentially measurement on the performance of measurement equipment, are a vital factor in sound engineering selection of measurement.

The three factors which enter into the selection of measurement are significance, application, and cost. Sound engineering judgment based on these factors is essential to selection of the necessary and sufficient measurements for optimum plant operation.

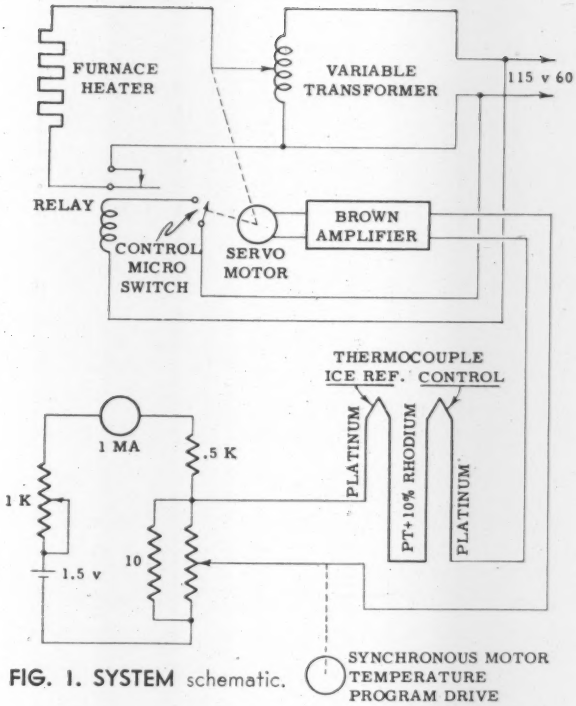


FIG. 1. SYSTEM schematic.

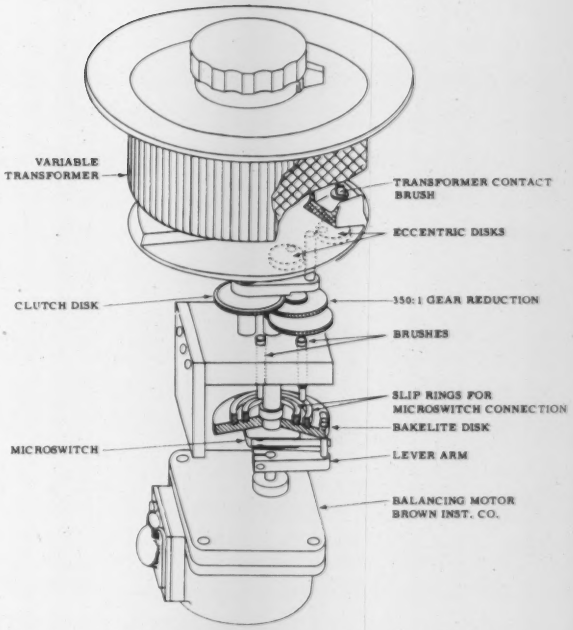


FIG. 2. MECHANISM for on-off control of furnace with reset.

On-Off Controller With Reset

W. B. MILLIGAN and C. J. PENTHER, Shell Development Company

IF the power base of a thermostat is varied to maintain equal on-off heater cycling, there will be the least temperature variance from the set point. When this is done automatically by using cumulative minute deviations of timing to position the slider of a variable transformer, a form of integral or reset control is attained. A simple device for this purpose has been devised to accommodate the wide range of heater power required for a time-programmed furnace.

The slider of a variable autotransformer supplying the heater is automatically motor-driven to a position maintaining equal on-off heater cycling. As shown in the schematic diagram, Fig. 1, the error signal is amplified by a standard Brown Electronik amplifier to drive a Brown servomotor. The motor closes and opens a Microswitch to turn the heater on and off as the thermocouple emf oscillates below and above the program potentiometer reference voltage. The motor also moves the contact arm of the variable autotransformer—*if* successive on (or off) cycles exceed off (or on) cycles.

The mechanism producing this control action is shown in Fig. 2. Connections for the Microswitch are brought out through slip rings mounted on the same bakelite disk as the Microswitch. A lever arm on the motor shaft extends through a slot on the slip-ring disk. This arm contacts the Microswitch flapper when in the middle of the slot; if equal on-off increments exist, this arm moves back and forth in this slot, turning the switch on and off without moving the slip-ring disk. If the on-off increments are not equal, however, the rotation travel is unbalanced and the arm hits the end of the slot and moves the disk that drives the gear reduction to the auotransformer.

The shaft of the disk is geared down 350:1 to rotate a second arm. The pin on this arm drives the variable-transformer contact by applying torque to either of two bakelite disks fastened to the contact arm of the transformer. The disk mounting holes are off center so that the space between them can be adjusted for the desired "backlash." The dead space permits the on-off control to average several cycles before moving the transformer contact and helps prevent "hunting."

The device corrects for steady-state demand change. The transformer reaches a final setting which results in equal on-off cycles and no offset of the control temperature. Speed of the correction for demand change depends on the rotational rate of the variable autotransformer and the backlash of its drive link. Therefore the rate should be set as high as possible and the backlash as small as possible, consistent with maintaining control stability.

This controller also has been used without programming (at fixed temperature) on jacketed laboratory distillation columns, and elsewhere where ambient temperature, thermal load or line voltage fluctuate. The variable autotransformer drive* may be used with any on-off controller by providing a reversible motor controlled by the heater relay.

*C. J. Penther, and W. B. Milligan, U. S. Patent No. 2,594,984 (April 29, 1952)

STUDENTS at The Bailey Meter Company 2-week general-instrumentation course.

Industrial-Instrument-Manufacturers' Schools

SEVERAL LEADING MANUFACTURERS of industrial instruments maintain schools offering tuition-free courses, with various curricula, of different duration and frequency, and on different levels. Most of these schools were started two to three decades ago, when the interest in industrial instrumentation first began to bloom. Originally designed to instruct the company's sales and service engineers, they also now train maintenance personnel in industrial plants and—of particular importance—educators in the field of industrial automation.

While the courses are given without obligation, it is understood that the student will defray his traveling expenses and living expenses while taking the course.

Bailey Meter Company

Bailey offers a two-week general instrumentation course each month except Feb. and Oct. Two or more lectures are given each day. These cover design, care, calibration, and application of meters and controls to the steam-power-plant and process fields. About half of each day is spent in the school-room work shop in actual calibration, adjustment and operation of various types of Bailey instruments and control components. The course outline follows.

First Week

Monday: Mechanically operated flowmeters.

Tuesday: Level recorders; pneumatic transmitters.

Wednesday: Combustion theory; air flow adjustment.

Thursday & *Friday*: Electronically operated Pyrotrons, flow meters, level and pressure transmitters, gas analysis apparatus.

Second Week

Monday: Control principles; Pilotrols, controllers; relays.

Tuesday: Standatrols, selector valves, control valves and drives.

Wednesday: Mini-Line relays and selector stations.

Thursday: Combustion, feed water, and steam temperature control systems.

Friday: Control adjustments, package boiler controls.

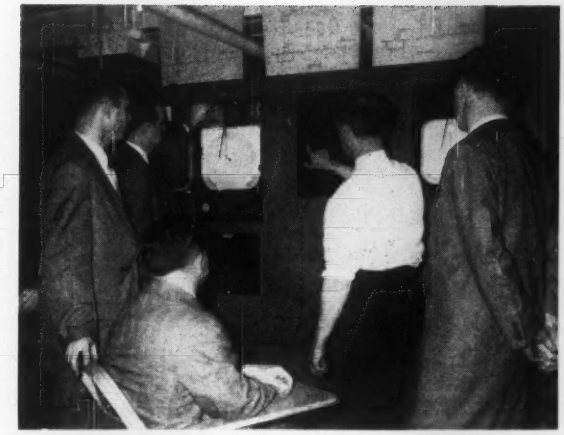
From time to time special training courses may be given on specific applications as the need becomes apparent and when sufficient personnel can be enrolled to justify the course. Such courses may cover Marine Combustion Control, Pyrotrons, Telemeters and Calculators, Instrument courses for specific Industries, etc.

Requests for admission to the course of selection: R. E. Sprenkle, Director of Education, Bailey Meter Company, 1050 Ivanhoe Road, Cleveland 10, Ohio.

The Foxboro Company

General Electric Company

The Bristol Company



SETTING a controller in typical Bristol class.

TEACHER of Bristol course gives four trainees briefing on instrument adjustment.

Bristol was one of the first instrument manufacturers to recognize the need for a training school. Regularly scheduled courses for customers' maintenance and operating personnel were begun in 1927. Today, group instruction is being offered in five different categories:

(1) A two-week general course on all the main types of instrumentation offered by Bristol, including pressure and vacuum gauges, thermometers, liquid level meters, flowmeters, pneumatic transmitters and controllers, process control valves, pyrometers, thermocouples, self-balancing electronic bridges and potentiometers, telemeters, electric and electronic controllers, voltmeters, ammeters, "Thermoverters," and pH and conductivity meters.

(2) A one-week "service" course on telemetering equipment with special emphasis on the Bristol Metameter telemeter line.

(3) A one-week course on Bristol analog computing systems.

(4) A one-week course on the Dynamaster line of self-balancing electronic potentiometers and bridges.

(5) A one-week course on miniature pneumatic instruments (Bristol's Metagraphic line) for process supervision and control.

Special classes are held on various other subjects whenever sufficient demand arises.

Requests for current schedules and admission forms: C. F. Johnson, Manager of Education, The Bristol Company, Waterbury 20, Connecticut.

Fischer & Porter

Fischer & Porter Company offers two types of courses on a regularly scheduled basis. The first, restricted to F&P field engineers, application engineers, and sales representatives, covers F&P products, sales policies, pricing and order handling, and competitive activities.

The second regularly scheduled training course, offered to instrument mechanics employed by F&P customers, covers servicing and repair of F&P instruments. One week in length, it is held three times yearly beginning the second Monday of January, April and September.

Special courses for customers' Instrument Engineers in theory, design and application also are given by arrangement. Course length is varied to suit individual requirements.

Requests for admission to the latter two courses should be sent to Mr. Horace F. Richter, Sales Coordinator, Fischer & Porter Co., Hatboro, Pa.

FISCHER & PORTER class covers principles and practice of flowmetering, process control, viscosity, etc.

Hagan Chemicals & Controls

Leeds & Northrup Company

The Foxboro Company

The Foxboro Company's Training Center was founded in 1935. The extent of the school facilities is illustrated by the number of students trained in 1957 —424—of which about half were technicians, half engineers. They represented 151 domestic companies and 35 foreign countries.

For the 1959 season, 16 three-week general-industry training courses have been scheduled, plus 2 short courses where the company's Dynalog instruments are covered in one week. Also four 2-week intermediate general-industry courses are planned wherein application engineering and advanced theory is stressed and elementary subject matter omitted.

FOXBORO classroom.

In the three-week courses, indicators, recorders and controllers for nearly all measurable variables are discussed by four full-time instructors, and the company's full line of products (including control valves and accessories) are dismantled, reassembled, and calibrated by the students. In addition, specialists in various fields lecture and consult on theory and applications. The modern classroom and equipment facilities are carefully designed for students. The schedule for 1 week of a typical 3-week general-industry course is as follows:

Monday: Manuals; pressure mechanisms; flow.

Tuesday: Flow; liquid level; density.

Wednesday: Orifice and flow calculations; flowmeter engineering; calibration.

Thursday: Bench work on above (extending through Friday morning).

Friday: Filled thermal systems; resistance bulbs; resistance Dynalogs.

The second week might cover Dynalogs, strain gage, conductivity, pH, thermocouples, magnetic flow and transducers, with the third week devoted to control valves and mechanisms, and Electronic Consotrol instruments.

Each class is limited to 18 men.

Requests for admission: W. H. Furry, Director of Training and Education Dept., The Foxboro Company, Foxboro, Mass.

General Electric Company

The Instrument Department of General Electric offers technical training on process and industrial instruments at West Lynn, Mass. Four hundred students have taken advantage of this program since its intion in 1954. Twelve basic courses of 1-, 2-, or 3-day duration are given as follows (frequency and sequence of course depends on demand).

P-1. 3-day courses on Potentiometric Recorder-controllers and Pneumatic Cnotrol.

P-2. 2-day courses on AC Bridge Recorder-controllers and Electric Control.

P-3. 2-day courses on Millivoltmeter Pyrometers and Resistance Thermometers.

P-4. 1-day courses on Primary Elements—thermocouples, resistance elements and other electrical tranducers

P-5. HF and HG strip-chart recorders.

TWO STUDENTS working at laboratory benches in General Electric's process instrument school.

The following courses are given on request only:

S-1: Spectrophotometer—includes study of theory of operation, adjustments of light source, optical systems, prisms, first surface mirror, Rochon and Wollaston lenses, photoelectric amplifier, and recording machanism.

S-2: Turbine-supervisory instruments.

S-3: Oscillographs.

S-4: Telemetering Systems.

S-5: Automatic Dispatching System.

S-6: Type M Leak Detectors—mass-spectrometer theory, electrometer, direct-current amplifier.

S-7: Halogen-type Leak Detectors.

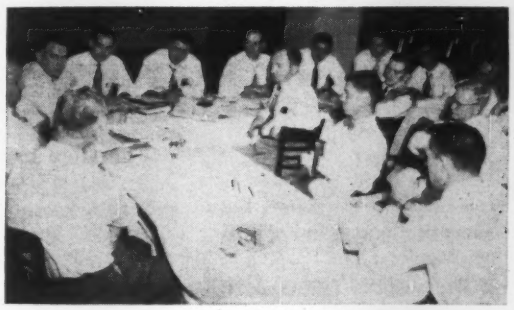
Requests for admission: Manager, Product Service, General Electric Company, Instrument Dept., West Lynn, Mass.

Hagan Chemicals & Controls

Hagan offers customers and educators six separate two-week courses on automatic control systems and metering equipment. Limited to an enrollment of 10 each, classes are conducted at the University of Pittsburgh (where Hagan maintains a complete laboratory), at the firm's J. M. Hopwood Research Laboratory in nearby Orrville, Ohio, and in the new Hagan Building in suburban Pittsburgh.

After reviewing basic principles and functions of individual control components—both pneumatic and electronic—each customer trainee is guided through the control diagram of his particular plant. Final two days of the 9-day sessions are spent in Orrville, observing methods of testing, assembly, shop calibrating procedures, panel piping and wiring.

Sessions this year are in June, July and August. Most of the nation's large steel, public power and petroleum companies send trainees to one or more of the sessions, as will the U. S. Navy and Harvard and John Hopkins Universities.



HAGAN COURSES cover theory and practice.

Of particular interest this year is Hagan's PowrMag solid-state, electronic control systems—utilizing magnetic amplification rather than transistor or vacuum-tube circuits. Class participants, already familiar with pneumatic control systems, will learn the basic differences and the many similarities between pneumatic and electronic systems, as well as learning where each type of system is best applied.

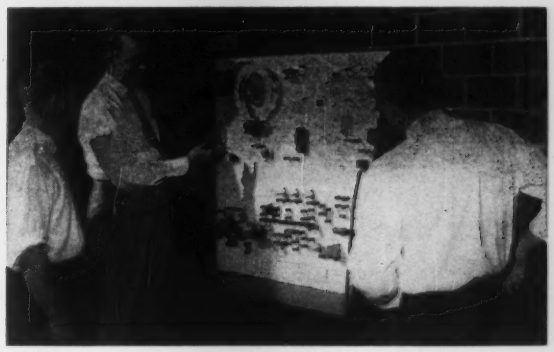
In addition to these annual courses, Hagan also offers special unscheduled classes on Ring Balance Meters and Kybernetes Electronic Data Processing equipment.

Requests for admissions: R. C. Cibella, Director of Education, Hagan Chemicals and Controls, Box 1346, Pgh. 30, Pa.

Leeds & Northrup Company

Leeds & Northrup offers three types of 2-week courses, based on the primary interest of the registrant —(1) metal working, metal refining and ceramics, (2) process industries, and (3) steam and electric power. The first week in all of these courses is devoted to measurements, and the second week to controls.

About 20 classes are taught each year and, since 1935, about 8800 students have been trained. Lecture and laboratory type instruction is given. The lecture classes are limited to 40 students and are broken into two groups of 20 students or less for laboratory work and question and answer sessions. Visual presentations are frequently used in the classroom.



L & N Training Center students adjust a Speedomax G (top) and trace circuitry (below).

The Process Industries curriculum includes:

A. Temperature—Thermoelectric pyrometers; Resistance thermometry; Radiation pyrometers; Optical pyrometer.

B. pH and Redox.

C. Conductivity and Analytical Measurements.

D. Primary Elements—Thermocouples; Resistance thermometers; pH electrodes; Redox electrodes; Conductivity cells.

E. Automatic Control (Electric-Pneumatic)—On-Off; Proportional; Reset; Rate time.

F. Specific Market Processes.

Requests for admission should be directed through the Leeds & Northrup office which serves the applicant.

Manning, Maxwell & Moore, Inc.

Manning, Maxwell & Moore offers one-week courses in electronic instrumentation in measurement, transmission, and control. The courses of instruction are divided over the five-day period as follows:

Monday—Introduction; explanation of Microsen balance; basic tuned-grid tuned-plate oscillator; bridge circuits. Principles of operation, calibration and maintenance of various types of electronic transmitters.

Shop session. Calibrating and trouble shooting techniques. Review and general questions on the day's topics.

Tuesday—Operation and demonstration of flow transmitter. How to achieve a linear output from a square-root function.

Operation, calibration, and maintenance of temperature transmitters. Indicating, recording, and signalling lecture. Demonstration of signal relay.

Wednesday—Indicating and recording electronically. Operation and calibration of recorders, pen recorders, indicators.

MICROSEN instructor with modular controller.

Controllers—operation, maintenance and calibration. Photo shows instructor holding modular controller.

Shop session.

Rate amplifier and product specification testing techniques. Operation, calibration, and maintenance.

Thursday—Tour of Stratford plant. Construction, calibration, and pre-delivery inspection standards. Application of Microsen instruments by industry and by plant.

Operation, calibration and maintenance of final elements. Review and general questions.

Friday—The hydraulic operator. Shop session. Demonstration of calibration, trouble shooting, and split-range techniques. Review of week's course.

In the week's course, ten application engineers act as lecturers. Specialists are also called in as needed.

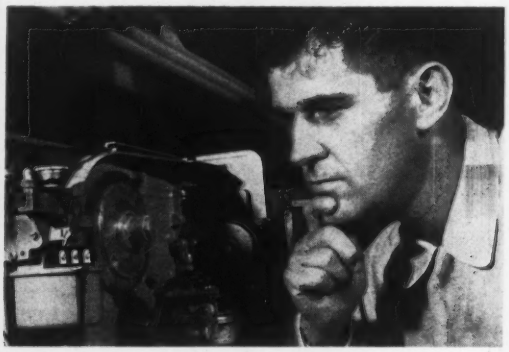
Requests for admission should be addressed to C. A. Bobb, Product Manager, Manning, Maxwell & Moore, Inc., Stratford, Conn.

Minneapolis-Honeywell Regulator Company Brown Instruments Division

A three-story building in Philadelphia houses Honeywell's Brown Instruments Division's Instrumentation Education Center. The school was founded in 1935. Since that time more than 5,000 "students" representing over 775 U. S. manufacturers have graduated from the school. Students from 37 different foreign nations also have graduated. Ten leading colleges have sent faculty members for study.

Courses cover pyrometry, electronic potentiometers, pneumatic and electric automatic control, flowmeters, thermometers, pressure gages, etc. Special courses are held for specific industries. For example, instrumentation for the textile, food, and paper fields may be arranged.

Classroom sessions run from 8:30 a.m. through 5 p.m. Monday through Friday.



STUDENT will be able to take recorder apart and put it back together again by the time he graduates from the Minneapolis-Honeywell course.

The schedule for a 5½-week short selective course is as follows (trainee may register for entire course or any part thereof)

Subject	Lecture Days	Lab Days
Pyrometry and ElectroniK Potentiometers	3	7
Pneumatic Control Systems	2	6
Flow Meters	2	6
Thermometers—Pressure Gauges—Hygrometers	1	4

The schedule for a 14-week comprehensive course is:

Subject	Lecture Days	Lab Days
Millivoltmeter Type Pyrometer	2	8
Mechanical Poteniometer Pyrometer	2	6
Continuous Balance (ElectroniK) Potentiometer	3	8
Electrically Operated Automatic Control	1	8
Flow meters	2	7
Thermometer—Pressure Gauge—Hygrometer	1	3
Pneumatic Control Systems	2	8
Moist-o-Graph	1	1½
Tachometer	½	1
Resistance Thermometer	1	½

Requests for admission: M. J. Ladden, Director of Education, Minneapolis-Honeywell Regulator Company, Wayne & Windrim Avenues, Phila. 44, Penna.

INTER-RANGE INSTRUMENTATION GROUP MAGNETIC RECORDER/REPRODUCER STANDARDS

These standards define terminology and specify the configuration and operating characteristics of magnetic recording/reproducing devices used for telemetry and airborne data collection applications at the missile test ranges, as abstracted from IRIG Document 101-57.

NORMAL RECORD LEVEL. The level of record head current required to produce 1% third harmonic distortion of the reproduced signal, when the distortion is a function of magnetic tape overload and is not a function of electronic circuitry.

MAXIMUM RECORD LEVEL. The level of record head current required to produce 3% third harmonic distortion of the reproduced signal, when the distortion is a function of magnetic tape overload and is not a function of electronic circuitry.

SPEED CONTROL SIGNAL. An amplitude-modulated signal recorded for the control of tape speed during the playback process.

COMPENSATION SIGNALS. Signals recorded on the tape along with the data and in the same track as the data, which are used during the playback of data to electrically correct for the effects of tape speed errors.

TIMING SIGNALS. Any signal recorded simultaneously with data for use during playback in data reduction applications.

Tape

The *standard tape widths* for all but special applications are ¼", ½" and 1" with the tolerance on all widths being +0.000", —0.004". A tape width of ½" is preferred where compatible with program requirements.

Standard speeds for the direct recording and playback of IRIG standard telemetry signals are 60 and 30 ips.

The standard magnetic-tape *reel sizes* are 10½" and 14" diameter reels.

Track Specifications

TRACK WIDTH. The track width for multiple-track recording shall be 0.050" ±0.005". Track width is defined as the physical width of the head which would be used to record or reproduce any given track, although the actual width of the recorded track will be somewhat greater because of the magnetic fringing effect around each recording head.

TRACK SPACING. Tracks shall be spaced 0.070" center-to-center across the tape and, as a group, shall be centered on the width of the tape. Therefore, the preferred tape width (½" width) would contain 7 tracks with 1 track located at the center of the tape.

TRACK NUMBERING. The tracks on a tape shall be numbered consecutively, starting with track number "one," from top to bottom when viewing the oxide-coated side of a tape with the earlier portion of the recorded signal to the observer's right.

Record/Reproduce Frequency Characteristics

The over-all frequency response characteristics of a tape recorder-reproducer are a function of the tape speed used. An instrumentation machine shall record and reproduce data with response in accordance with Table 1. The 30 ips tape speed response is adequate for recording IRIG FM subcarriers up to and including 30 kc and for recording IRIG standard PDM signals.

TABLE 1—OVER-ALL RECORD/REPRODUCE FREQUENCY-RESPONSE CHARACTERISTICS

Tape Speed (in/sec.)	±3 DB Pass Band (CPS)
60	300-100,000
30	300- 50,000

The record amplifier shall be designed and connected to the recording head in such a manner that the signal current in the head for constant voltage supplied to the amplifier input does not vary more than ±2% over the pass bands given in Table 1.

The reproduce amplifier shall be connected to the reproduce playback head and shall be designed to compensate (by use of suitable equalization circuitry) for magnetic-tape and record- and reproduce-head characteristics in such a manner that the over-all record/reproduce frequency characteristics of Table 1 are obtained.

Speed Control Signal

The speed control signal is an amplitude-modulated signal with the following characteristics:

Subcarrier Frequency—17.0 kc ±0.02%
Modulating Frequency—60 cps ±0.02%
Percentage Modulation—50% ±5%
Operating Level—10 db, ±5 db, below normal record level

Compensation Signals

Compensation signals (to be used for correction of tape speed error effects) are a function of tape speed as follows:

Tape Speed	Compensation Tone Frequency
30 ips	50 kc ±0.01%
60 ips	100 kc ±0.01%

IRIG Document 101-57 can be obtained from Armed Services Technical Information Agency, Document Service Center, Knott Bldg., Dayton 2, Ohio

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Shop session. Calibrating and trouble shooting techniques. Review and general questions on the day's topics.

Tuesday—Operation and demonstration of flow transmitter. How to achieve a linear output from a square-root function.

Operation, calibration, and maintenance of temperature transmitters. Indicating, recording, and signalling lecture. Demonstration of signal relay.

Wednesday—Indicating and recording electronically. Operation and calibration of recorders, pen recorders, indicators.

MICROSEN instructor with modular controller.

Controllers—operation, maintenance and calibration. Photo shows instructor holding modular controller.

Shop session.

Rate amplifier and product specification testing techniques. Operation, calibration, and maintenance.

Thursday—Tour of Stratford plant. Construction, calibration, and pre-delivery inspection standards. Application of Microsen instruments by industry and by plant.

Operation, calibration and maintenance of final elements. Review and general questions.

Friday—The hydraulic operator. Shop session. Demonstration of calibration, trouble shooting, and split-range techniques. Review of week's course.

In the week's course, ten application engineers act as lecturers. Specialists are also called in as needed.

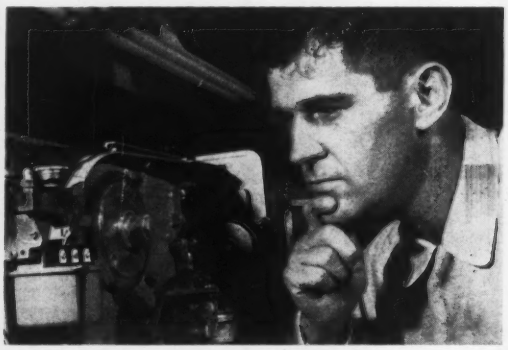
Requests for admission should be addressed to C. A. Bobb, Product Manager, Manning, Maxwell & Moore, Inc., Stratford, Conn.

Minneapolis-Honeywell Regulator Company Brown Instruments Division

A three-story building in Philadelphia houses Honeywell's Brown Instruments Division's Instrumentation Education Center. The school was founded in 1935. Since that time more than 5,000 "students" representing over 775 U. S. manufacturers have graduated from the school. Students from 37 different foreign nations also have graduated. Ten leading colleges have sent faculty members for study.

Courses cover pyrometry, electronic potentiometers, pneumatic and electric automatic control, flowmeters, thermometers, pressure gages, etc. Special courses are held for specific industries. For example, instrumentation for the textile, food, and paper fields may be arranged.

Classroom sessions run from 8:30 a.m. through 5 p.m. Monday through Friday.



STUDENT will be able to take recorder apart and put it back together again by the time he graduates from the Minneapolis-Honeywell course.

The schedule for a 5½-week short selective course is as follows (trainee may register for entire course or any part thereof)

Subject	Lecture Days	Lab Days
Pyrometry and ElectroniK Potentiometers	3	7
Pneumatic Control Systems	2	6
Flow Meters	2	6
Thermometers—Pressure Gauges—Hygrometers	1	4

The schedule for a 14-week comprehensive course is:

Subject	Lecture Days	Lab Days
Millivoltmeter Type Pyrometer	2	8
Mechanical Poteniometer Pyrometer	2	6
Continuous Balance (ElectroniK) Potentiometer	3	8
Electrically Operated Automatic Control	1	8
Flow meters	2	7
Thermometer—Pressure Gauge—Hygrometer	1	3
Pneumatic Control Systems	2	8
Moist-o-Graph	1	1½
Tachometer	½	1
Resistance Thermometer	1	½

Requests for admission: M. J. Ladden, Director of Education, Minneapolis-Honeywell Regulator Company, Wayne & Windrim Avenues, Phila. 44, Penna.

INTER-RANGE INSTRUMENTATION GROUP MAGNETIC RECORDER/REPRODUCER STANDARDS

These standards define terminology and specify the configuration and operating characteristics of magnetic recording/reproducing devices used for telemetry and airborne data collection applications at the missile test ranges, as abstracted from IRIG Document 101-57.

NORMAL RECORD LEVEL. The level of record head current required to produce 1% third harmonic distortion of the reproduced signal, when the distortion is a function of magnetic tape overload and is not a function of electronic circuitry.

MAXIMUM RECORD LEVEL. The level of record head current required to produce 3% third harmonic distortion of the reproduced signal, when the distortion is a function of magnetic tape overload and is not a function of electronic circuitry.

SPEED CONTROL SIGNAL. An amplitude-modulated signal recorded for the control of tape speed during the playback process.

COMPENSATION SIGNALS. Signals recorded on the tape along with the data and in the same track as the data, which are used during the playback of data to electrically correct for the effects of tape speed errors.

TIMING SIGNALS. Any signal recorded simultaneously with data for use during playback in data reduction applications.

Tape

The *standard tape widths* for all but special applications are ¼″, ½″ and 1″ with the tolerance on all widths being +0.000″, —0.004″. A tape width of ½″ is preferred where compatible with program requirements.

Standard speeds for the direct recording and playback of IRIG standard telemetry signals are 60 and 30 ips.

The standard magnetic-tape *reel sizes* are 10½″ and 14″ diameter reels.

Track Specifications

TRACK WIDTH. The track width for multiple-track recording shall be 0.050″ ±0.005″. Track width is defined as the physical width of the head which would be used to record or reproduce any given track, although the actual width of the recorded track will be somewhat greater because of the magnetic fringing effect around each recording head.

TRACK SPACING. Tracks shall be spaced 0.070″ center-to-center across the tape and, as a group, shall be centered on the width of the tape. Therefore, the preferred tape width (½″ width) would contain 7 tracks with 1 track located at the center of the tape.

TRACK NUMBERING. The tracks on a tape shall be numbered consecutively, starting with track number "one," from top to bottom when viewing the oxide-coated side of a tape with the earlier portion of the recorded signal to the observer's right.

Record/Reproduce Frequency Characteristics

The over-all frequency response characteristics of a tape recorder-reproducer are a function of the tape speed used. An instrumentation machine shall record and reproduce data with response in accordance with Table 1. The 30 ips tape speed response is adequate for recording IRIG FM subcarriers up to and including 30 kc and for recording IRIG standard PDM signals.

TABLE 1—OVER-ALL RECORD/REPRODUCE FREQUENCY-RESPONSE CHARACTERISTICS

Tape Speed (in/sec.)	±3 DB Pass Band (CPS)
60	300-100,000
30	300- 50,000

The record amplifier shall be designed and connected to the recording head in such a manner that the signal current in the head for constant voltage supplied to the amplifier input does not vary more than ±2% over the pass bands given in Table 1.

The reproduce amplifier shall be connected to the reproduce playback head and shall be designed to compensate (by use of suitable equalization circuitry) for magnetic-tape and record- and reproduce-head characteristics in such a manner that the over-all record/reproduce frequency characteristics of Table 1 are obtained.

Speed Control Signal

The speed control signal is an amplitude-modulated signal with the following characteristics:

Subcarrier Frequency—17.0 kc ±0.02%
Modulating Frequency—60 cps ±0.02%
Percentage Modulation—50% ±5%
Operating Level—10 db, ±5 db, below normal record level

Compensation Signals

Compensation signals (to be used for correction of tape speed error effects) are a function of tape speed as follows:

Tape Speed	Compensation Tone Frequency
30 ips	50 kc ±0.01%
60 ips	100 kc ±0.01%

IRIG Document 101-57 can be obtained from Armed Services Technical Information Agency, Document Service Center, Knott Bldg., Dayton 2, Ohio

Measuring transient pressure accurately requires selecting from a multiplicity of models and designs of transducers with different dynamic properties. Response of interconnecting tubing must be considered. Simulation is strongly recommended for each transducer.

Dynamic Response Of

ROBERT J. REID
EDWARD M. KOPS

Convair (San Diego)

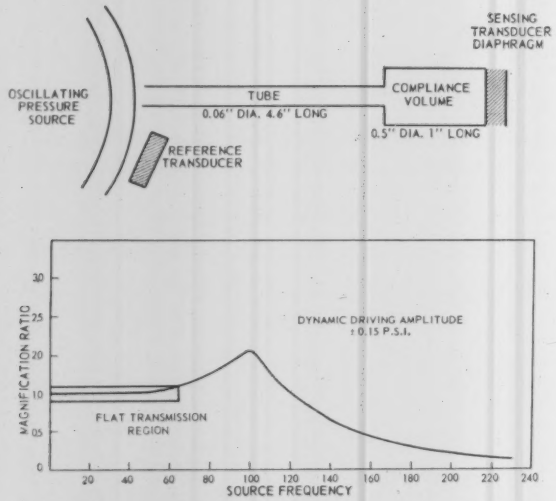


FIG. 1. CONNECTING TUBE and volume chamber for remote transducer, and typical frequency-response characteristic. Resonance effect is due primarily to connecting tubing and the compliance volume.

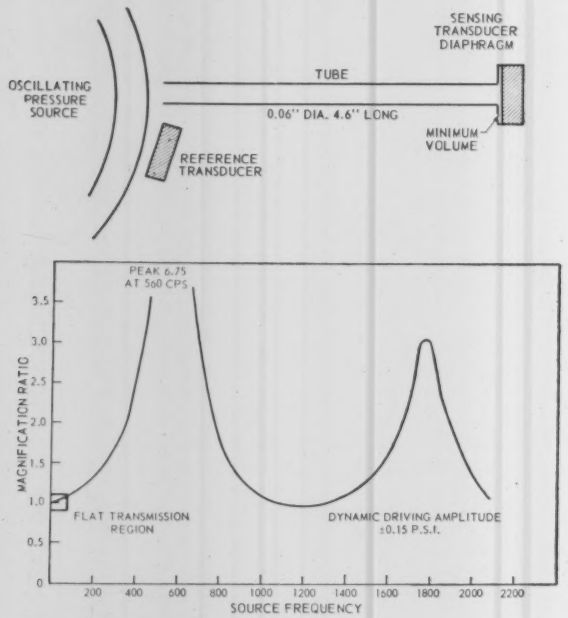


FIG. 2. MINIMUM-VOLUME transducer chamber and its effect on frequency-response characteristic.

SMALL flush-diaphragm transducers are a popular means for sensing pressures, particularly transient pressures. These transducers have been available for several years and have a surprisingly large usable frequency range. Typical sensors have a 0.5″ diameter diaphragm built flush with one end of the transducer and unbonded strain-gage-bridge internal construction. The diaphragm, when carefully mounted in a plane surface, becomes a smooth part of the surface, thus presenting an optimum way to measure pressures acting on the surface.

Remote Transducer Considerations

Many times, however, we find that the chamber is curved abruptly, so that the diaphragm does present an irregularity, or the model is too small, or perhaps the temperature is too high, making remote sensing mandatory. Other reasons necessitating remote installation may be environmental, such as transient temperature, high vibration, and shock. (Transient temperatures can seriously affect those transducers compensated for slow-changing ambient temperatures, and sensitive transducers can be excited by sound to mechanical resonance and so require the isolation provided by a more remote mounting location.) Choosing a remote installation introduces one set of difficulties for another if we wish to measure dynamic pressure. The connecting transmission system introduces its response characteristics; moreover, these characteristics can be expected to change with shifts of operating pressure, temperature, dynamic amplitude, and frequency. Means for determining the optimum remote sensing configuration are needed.

Uniform tubes usually have standing-wave characteristics, or, if the tube is terminated in an enclosed volume, a second-order resonant pneumatic system is present. This is analogous to the familiar spring-mass resonance of mechanical systems—the air rushing back and forth in the tube has the characteristics of mass, while any enclosed volume at the end of the tube acts as a compliance area which stores energy

Remote Pressure Pickups

in a manner analogous to a spring. Roughness of the tube walls and restrictions impede flow in the tube and use energy, thereby providing viscous damping to the pneumatic resonant system.

Transmission Frequency Response

Fig. 1 is a diagram of a typical pneumatic resonant configuration and its corresponding response curve. It can be seen that this curve shape corresponds closely to one of the curve shapes found in standard families of second-order response curves. Damping for this curve is 0.32 critical.

At low frequencies there is a 1-to-1 ratio between the input signal amplitude and the signal amplitude passed through the pneumatic system to the transducer. However, as we approach resonant frequency, amplification takes place. The shaded section of Fig. 1 covers the most accurate signal transmission spectrum of the pneumatic sensing system (10% is considered maximum tolerable error).

Use of the resonant region even by correcting for the unwanted amplification effects is difficult due to nonlinear effects to be discussed. Yet often in installations requiring remote transducer location, a still longer flat-frequency range is desired—i.e., we wish to extend the shaded part of the response curve to include a longer and larger frequency range.

It might be concluded that the resonant frequency would be increased by doing away with the volume. Fig. 2 shows a system with reduced volume. The frequency of maximum oscillation is much higher (560 cps compared to 100 cps in Fig. 1)—but the amplification at this frequency also is much higher. The resulting increase of usable frequency range is relatively small and is obtained at considerable sacrifice because even a small signal applied at the resonant frequency of the tube can interfere with analysis of data in the accurate spectrum. Resonance amplifications of eight times or more have been measured with small volumes. This is a standing-wave resonance which differs in many respects from that in the first pneumatic system. The frequency of maximum oscillation is determined by the tube length, and harmonics of sizable effect will be found at approximate odd multiples of the fundamental frequency, decreasing in amplitude exponentially with higher frequencies. Also, should the transducer's mechanical resonant frequency correspond to one of the pneumatically

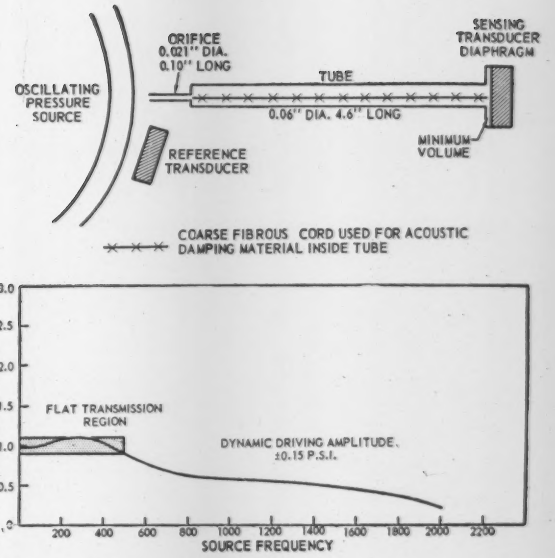


FIG. 3. REDUCING TUBE diameter at the test chamber and inserting a fibrous cord for damping combine to produce the improved frequency-response characteristic shown.

resonant peaks, there is serious danger of destroying even rugged transducers through this double-resonance effect.

Combination Pickup

The need for high-response transmission systems with relatively flat characteristics has led to some unique constructions. Introduction of some volume to the system, but not as much as in Fig. 1, will result in a combination system with response characteristics that become more like that of Fig. 1 as more volume is introduced. A useful design is shown in Fig. 3, which combines several features into a probe with an optimized flat (±10% error) transmission region.

A small tube introduced at the sensing end of the system can attenuate the violent oscillations that take place in the transmission tube. Restricting the orifice more and more has resulted in undesirable effects and, in some cases, it appears more desirable to provide a coarse acoustically absorbent lining within the main tube to reduce the oscillations at resonance. A coarse fibre cord of some resilient fibrous material is a convenient way of providing the ascoustical absorption with the uniform tube. In effect, the inductance properties of the tube are very much diminished by the addition of the absorbing material. An expanded usable frequency spectrum results from these improvements, and the effects of higher-order harmonics disappear as well.

Probes of this general design are being used by Convair to measure high-frequency pressure fluctuations and transients in wind-tunnel models, aircraft engines, ducts and, in special cases, to measure high-intensity sound within the usable frequency spectrum of the probes. These measurements have been ob-

tained under conditions where use of more conventional methods would have been extremely difficult.

The three curves presented are from experimental measurements. All measurements were done at one amplitude of dynamic pressure and at sea-level ambient pressure. It is recommended that an experimental verification be made of all probes contemplated for use by simulating both the static pressures expected and the dynamic pressure predicted.

The effects of different signal amplitudes and ambient pressures can be predicted. The resonant magnification ratio decreases for larger-amplitude input signals. Conversely, smaller signals produce larger magnification ratios. Also, greater resonance-effect (magnification) can be expected as the absolute value of the ambient pressure gets larger. On the other hand, little magnification is observed when the transients are fluctuating about an ambient pressure corresponding to 50,000′ or more altitude. The net effect of these varying parameters is a reduction in span of the accurate transmission spectrum. Where the measurements are to be made on aircraft which will operate through many altitudes, considerable simulation should be done to be assured of enough usable frequency range in the probe for all measuring conditions. Some success has been achieved in predicting effects of altitude, etc., for the simpler systems, but analysis has not been developed for the more complex construction, such as that of Fig. 3.

The information presented was obtained by exciting a small symmetrical diffusion chamber with an acoustic speaker-driven unit normally used to drive an exponential horn. Matched transducers were coupled symmetrically to the chamber, one with the experimental probe and one without, so that results were obtained on a comparative basis. Fluctuating pressures up to ±1 psi could be obtained through a limited frequency range directly from the speaker-driver unit. Dynamic pressures of much greater amplitude can be obtained by using resonant tubes which must be adjusted in length to obtain various frequencies.

Acoustic Measurements

This discussion has been confined to dynamic pressure-measuring instrumentation, but measurements normally considered acoustic can be made by probe microphones which make use of a length of tube brought to the microphone by an adapter. If narrow-band analysis of data is of interest, there is serious objection to the use of a probe microphone in conjunction with a tube. A response curve similar to that of Fig. 2 can be expected to be generated for the standing waves whether the transducer is a microphone or a pressure sensor. A special type of microphone probe should be used which passes the sound across the microphone and into a long tube where it is absorbed.

Knowledge of these general principles will provide a way toward achieving more reliable dynamic-pressure measurements. With increasing aircraft speeds and temperatures, it appears that increasing interest will be directed to dynamic-pressure investigations.

VISCOSITY

AS PART of the National Bureau of Standards program to develop techniques and instruments for measuring properties of materials at high temperatures, the Bureau's glass laboratory is developing an "oscillating-cup" viscometer to measure the viscosity of liquid inorganic oxides at temperatures up to 2000°C or higher.

Before such data can be obtained for temperatures above 1500°C, the array of problems that confront nearly all high-temperature measurements must be met effectively. Among the more serious difficulties are those of corrosion and vaporization at high temperatures. Also, for greater dimensional stability and reproducibility, it is desirable that the instrument be simple in shape and construction.

In the case of viscosity measurement, there is an additional specific requirement. At sufficiently high temperatures the viscosity becomes so small it can no longer be measured by the techniques in common use

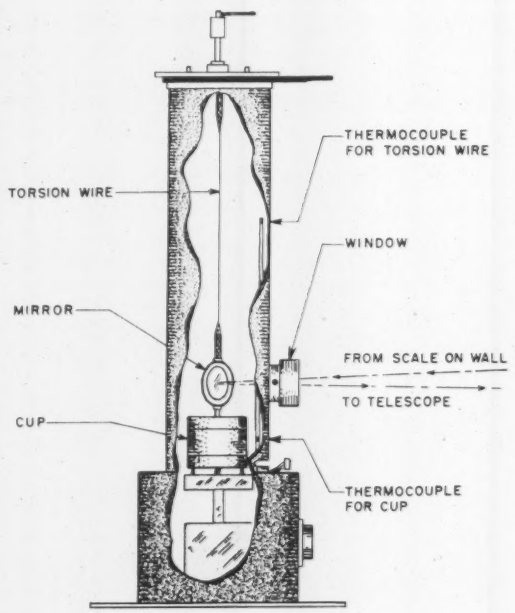


FIG. 1. DRAWING of prototype high-temperature viscometer. Liquid to be measured is placed in cup and viscosity is determined from damping effect of liquid on torsional vibrations of the cup. The three prongs fit into depressions in bottom of cup; turning the knob (lower right) causes prongs to move cup to desired initial angular position. Electromagnet at bottom draws prongs downward to release cup and start vibrations. Controls at top are for centering and other mechanical adjustments of the torsion pendulum.

MEASUREMENTS ABOVE 2000°C

for liquids. The instrumentation must therefore be suitable for measuring low liquid viscosities well below the order of 1 centipoise (approximately that of water) for the inorganic oxides.

Oscillating-Cup Principle

The oscillating-cup method appears to be adaptable to the requirements mentioned. The principle of operation is simple. The sample liquid is enclosed in a cup which is suspended from a wire to form a torsion pendulum (Fig. 1). When torsional vibrations are started, the presence of the liquid causes them to be damped. As the amount of damping depends on the viscosity, the latter can be calculated from the observed rate at which the vibrations decay. The mathematical problem of deriving the viscosity from the rate of decay is complex, but an adequate approximate solution is available using a high-speed computer.

Decay of amplitude of vibration is exponential with time and only a few oscillations need be observed to establish the decay rate. This increases the range of viscosities which can be measured in the relatively short times over which the high temperatures are maintainable. However, the method is primarily applicable for relatively low viscosities; higher viscosities would require inconvenient cup dimensions.

A prototype of an oscillating-cup apparatus has been constructed to investigate this method of measurement as applied to liquids (Fig. 2). Measurements were made on oils having known viscosities in the range of interest and were carried out at room temperature and up to several hundred degrees centigrade. The results show that the technique is satisfactory as a means of measuring low liquid viscosities. Parallel studies have also been made with a view to selecting materials and modifying the design to adapt it to use at high temperatures, and design of a high-temperature model is now well advanced.

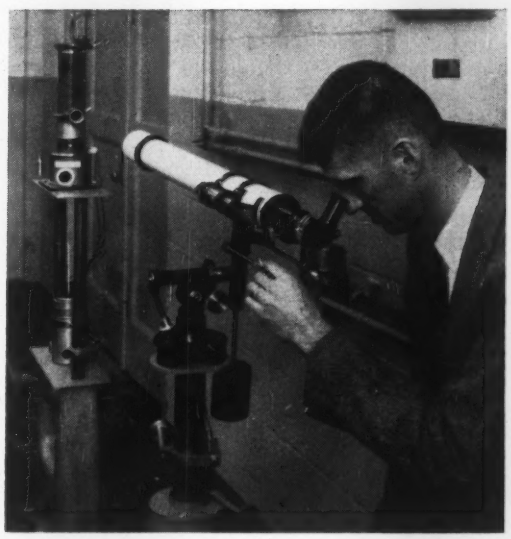


FIG. 2. PROTOTYPE of National Bureau of Standards instrument for measuring viscosity of liquid inorganic oxides at temperatures up to 2000° and higher. Liquid is held in closed cup suspended inside cylindrical housing (left) to form a torsion pendulum. Viscosity is determined from damping effect of liquid on torsional vibrations. Scientist follows vibrations by directing telescope to mirror attached to pendulum; mirror reflects scale on wall (not visible).

High-Temperature Design

Studies of the corrosive effect of boron trioxide on molybdenum, tungsten, and tantalum at temperatures up to 2100°C, have been made for the glass laboratory by Wright Air Development Center. These studies show that of these metals molybdenum offers the most resistance to corrosion, with the other 2 following in the order named. The cup will be protected from oxidation by operating it in a vacuum or in an inert atmosphere such as nitrogen or argon made slightly reducing by addition of a few percent of hydrogen. It is expected that this material will prove satisfactory for temperatures as high as a few hundred degrees above 2000°C.

High temperatures will be produced by induction heating and will be measured by optical pyrometry. Maintenance of a constant uniform temperature will be facilitated by the relatively small size of the oscillating cup as compared with the measurement cells of familiar types of liquid viscometers.

The cup will be affixed to a rigid rod which will extend outside the high-temperature zone, so that all moving parts of the apparatus except the cup can be maintained at lower temperatures where their operation is much more convenient. The rod is to be suspended from a torsion wire on which the rod and measurement cup oscillate as a unit. Measurement of the vibration amplitude will be made with a telescope (Fig. 2) directed towards a mirror attached near the top of the rod.

In addition to the work on the oscillating-cup viscometer, it is planned to explore the possibility of determining viscosity at high temperature from measurements on the damping of ultrasonic oscillations of a small probe immersed in the experimental liquid.

Process Control Systems

FRED D. MARTON, Instruments Publishing Company

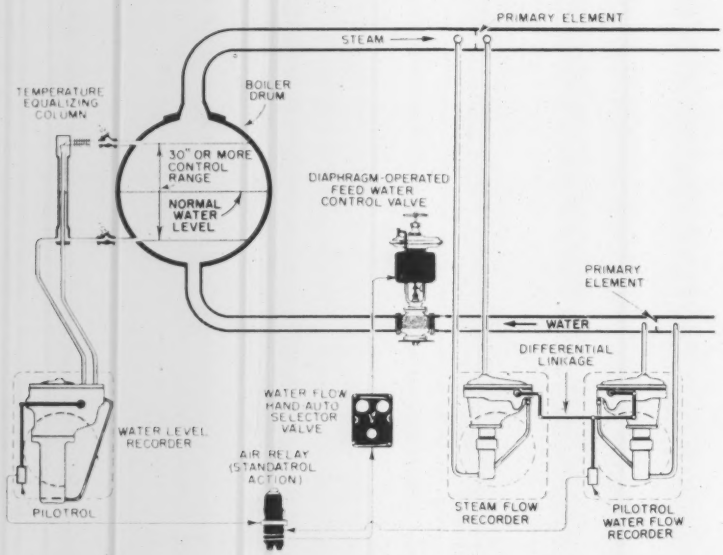
THREE-ELEMENT PILOT-OPERATED FEEDWATER CONTROL

This system is a three-element pilot-operated system. To the two-element system, a water flowmeter has been added, measuring the feedwater flow to the boiler by orifice or flow nozzle.

Primary control is from the *ratio of steam flow to water flow*, acting through a pilot valve (Pilotrol), having set point and proportional band adjustments, and through the Standatrol and Hand-Automatic Selector Valve to the feedwater regulating valve. The ratio action is produced by mechanical linkage to the Pilotrol. The valve is positioned not only by a change in steam demand but also by the water-flow measurement so that the waterflow input is equal to the steam-flow output from the boiler. Hence any variation in *feedwater pressure* ahead of the valve, causing a change in water flow, is immediately detected by the water flowmeter, and the valve repositioned to maintain the proper water flow before any effect on level is experienced.

As a final check and to assure proper drum level, the pneumatic signal from the Pilotrol in the water level recorder readjusts the feedwater control valve, if readjustment is needed.

The Standatrol provides reset action. The pilots have proportional band adjustments. The manual/automatic selector valve shown includes a valve-position indicator and provides manual adjustment during startup and abnormal operating conditions. The feedwater regulating valve is a double-seated globe-type valve equipped with positioner and hand-jack. The system controls level to less than 1″ when normal operation is restored after a sudden drop of up to 50%.



Basically, this is the type of control used on practically all of large utility boilers, and large industrial boilers in operation today. A selection chart is available to guide the user in choice of system. Of course no chart can cover all individual cases, and all factors should be investigated thoroughly before making a selection.

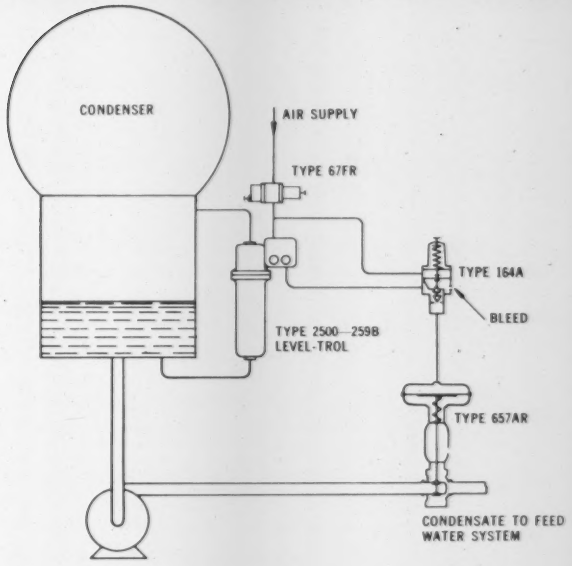
Either a diaphragm-operated or piston-operated feedwater control valve can be used, depending on requirements.

Source: Bailey Meter Co., Cleveland, Ohio.

LOCK-UP SYSTEM USES SMALL THREE-WAY CONTROL VALVE TO GUARD AGAINST PLANT AIR FAILURE

In the event of plant-air failure various installations require a different approach to the problem of valve position in the line. Some systems are designed to make the valve close when plant air fails, others throw the valve wide open, and some require that the last valve position be maintained. This system maintains last valve position. It is used in a boiler installation, where it is essential to maintain the flow from the condenser in the feedwater line. It uses a simple three-way diaphragm control valve (Type 164A) to lock up the pressure on the diaphragm of the main valve in the feedwater line when air pressure fails to supply the pneumatic level controller.

Level in the condenser is maintained by a controller (Type 2500-259B Level-Trol) which has a fabricated-steel float cage and furnishes proportional control action. Output from the controller is piped through the three-way control valve to the top of the diaphragm in the main control valve (Type 657AR, double-seated, air-to-open) in the feedwater system. Air, reduced by a simple Type 67FR regulator, supplies the Level-Trol, and also supplies the underside of the diaphragm in the three-way valve, keeping the port to the main valve



open and closing the plug which would bleed the control signal to the atmosphere.

In the event of plant air failure, the spring in the three-way valve closes the valve leading to the top of the main diaphragm, locking the air up, and bleeds the control signal from the Level-Trol to atmosphere.

Source: Fisher Governor Co., Marshalltown, Iowa.

MANUAL STRIP PICKLING CONTROL FOR BATCH PRODUCTION

Strip pickling in former years was a wasteful process; sulfuric acid, the main pickling agent, was added at random. The system shown adds acid to the pickling tanks in measured quantities.

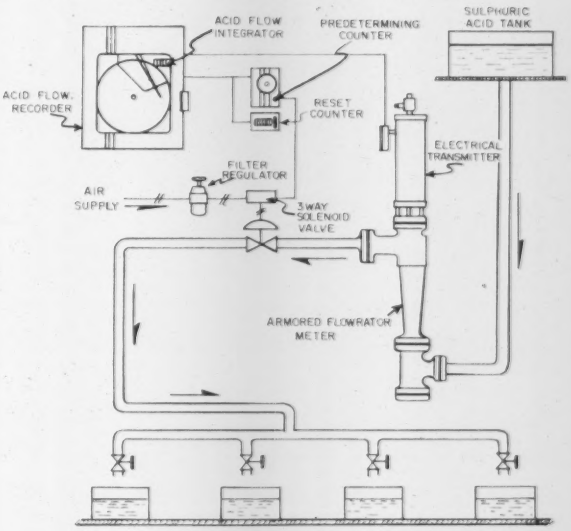
The system is based on four separate pickling tanks, in which the strip is dunked in succession. The tanks contain the pickle solution, which is heated by steam jets. As the solution does not flow, iron sulphate can build up on the bottom of the tanks and reduce production. Thus the batch method has mostly given way to a continuous operation; but the equipment installation can be kept intact as a stand-by because it affords the advantage of cleaning a tank while the other tanks can be kept in operation without interruption of the whole process. Also, this batch-control system can be used for new tank make-up or spot additions in batch-type pickling.

A Fischer & Porter Alloy 20 armored "Flowrator" meter with an electrical transmitter is installed in the main acid flow line between the storage tank and the various pickling tanks. The rate of flow measured is transmitted electrically to a remote recording and totalizing instrument. An on-off air-operated valve is installed in the same acid line and is actuated through a 3-way air solenoid.

To provide for automatic transfer of a desired quantity of acid, the sequence of the operation is as follows: the operator opens the hand valve to the designated pickling tank and then sets the dial of the predetermining counter for the quantity of acid to be transferred. The system is then energized by pushing the START button on the predetermining counter, which holds a clutch coil in an open position and energizes the solenoid which admits air to the diaphragm, opening the main control valve. The flow of acid continues until the impulses of the integrator of the flow-meter equal in number the pre-setting of the counter, at which time the clutch coil is tripped and the solenoid is de-energized; this immediately exhausts air from the valve diaphragm and closes it. Each of the flow-metering impulses is accumulated on a counter so that the total amount of acid used is available.

The quantities to be added are based on experience with the equipment.

Source: Fischer & Porter Co., Hatboro, Penna.; also W. H. Stuck "Strip Pickling Requires Acid Control," *Instruments & Control Systems*, March 1955.



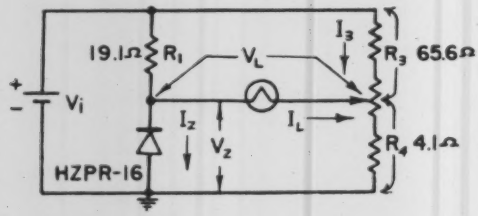
ELECTRONIC

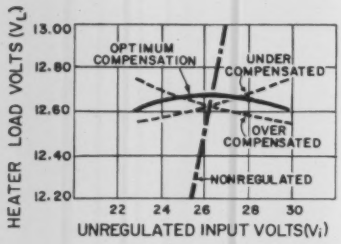
The circuit is the heart of all electronics. Here are 3 more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.

IMPROVED HEATER VOLTAGE REGULATOR USES ZENER BRIDGE

A previous circuit (*I&CS, Dec.* 1958) uses a 12-v zener diode, operating from a 26.5-v d-c power source, to regulate a 12-v vacuum-tube heater voltage. For a 300-ma heater, an input voltage change of ±13% was reduced to ±1.7% at the load. In this circuit, the internal impedance of the zener diode is compensated to reduce load voltage change to only ±0.4% for the same input voltage change, using a bridge circuit.

Zener regulator is a Hoffman type HZPR-16 (1N135C), which has a zener voltage of 16 and internal resistance of 1.2 ohms. In the bridge circuit shown, voltage at the junction of R_3 and R_4 changes by the amount needed to compensate for the increase in voltage drop across the zener diode due to its internal resistance (nominally 1.2 ohms). Compensation is not perfect because the internal resistance of the zener diode changes with current. As the curves show, the bridge trimmer resistor (between R_3 and R_4) can be adjusted to obtain overcompensation, with load voltage *rising* for decreasing supply voltages.





Circuit values may be computed as for any other Wheatstone bridge, taking into account zener current and load current. While the bridge is not balanced for direct current, because of the drop across the zener diode, it is balanced for a-c—that is, changes in input voltage.

Bridge resistor values may be computed from these three equations:

$$R_1 = \frac{V_i - V_z}{I_z + I_L}$$

$$R_4 = \frac{V_z - V_L\left(\frac{R_1 + R_z}{R_1}\right) - (I_z + I_L)\,R_z}{I_L}$$

$$R_3 = R_4\left(\frac{R_1}{R_z}\right)$$

where V_i is the center value of the input voltage
V_z = zener diode terminal voltage
I_z = zener diode current, chosen as 0.25 amp in the circuit shown
I_L = load current
R_z = zener diode internal resistance, and other symbols are as shown on the circuit.

A trimmer resistor between R_3 and R_4 should be used as shown to adjust for variations in zener voltage and internal resistance within tolerance. Trimmer is adjusted for best regulation. Value of the trimmer should be about 20% of calculated value of R_4, and the fixed portion of R_4 should be set at 10% less than its calculated value.

Equally good regulation can be obtained for 12.6-v 150-ma heaters, changing circuit resistances as computed from the above equations. For 6.3-v heaters a 12-v zener diode (type HZPR-12) is used; regulation is ±0.4% as before with 300-ma heaters, but only ±0.8% with 600-ma 6.3-v heaters. Circuit is not limited to vacuum-tube heaters; it can be applied also to other d-c loads which are reasonably constant in resistance.

Input: 23-30 v dc, at 850-ma nominal.

Output: 12.7-v dc at 300 ma, regulated.

Voltage regulation: ±0.4% change in output voltage for input voltage variation from 23-30 v.

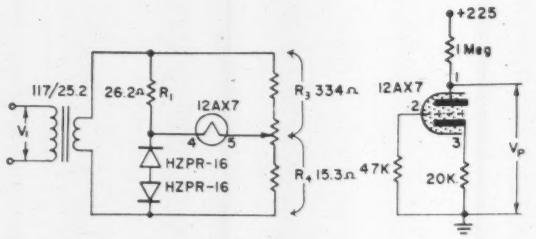
Load regulation: Calculations were made only for constant load conditions.

Source: Hoffman Electronics Corp., Semiconductor Div., 930 Pitmer Ave., Evanston, Ill.

NEAR-PERFECT A-C HEATER VOLTAGE REGULATOR USES ZENER BRIDGE

Regulation of a-c heater voltage by back-to-back zener diodes was shown in previous circuits.* As the regulated voltage is non-sinusoidal, regulation was measured by noting the change in amplifier plate voltage when line voltage was varied. In the present circuit, zener-diode internal impedance is compensated for in a bridge circuit and changes in amplifier plate voltage were so small as not to be detectable with a 0.05% sensitive voltmeter.

*Instruments & Control Systems, Nov., 1958



CIRCUITRY

CHARLES F. KEZER
and
MILTON H. ARONSON

Previous circuit offered only an improvement of 7.5 times over unregulated operation.

Two 16-v power zener diodes, Hoffman type HZPR-16 (IN135C) are connected back-to-back in a leg of the bridge. Bridge resistor values were computed for d-c operation, as shown in the preceding circuit; only slight readjustment for best regulation was required.

Circuit was tested also in modified form for regulating 6.3-v 300-ma heaters, using both a 6SU7 tube and the 12AX7 tube connected for 6.3-v operation. As with the 12AX7 tube operating from 12.6 v, no detectable change in plate voltage was observed as line voltage was varied over the 100-130-v a-c range. For the 6.3-v tubes, zener diodes were replaced by 12-v type HZPR-12, R_3 was changed to 428 ohms, and R_4 was changed to 16.3 ohms.

Input: 100-130 v ac rms.

Output: Sine wave clipped to ±12 v peak; nominal load current, 150 ma rms.

Voltage regulation: Output change not detectable, using amplifier circuit shown.

Source: Hoffman Electronics Corp., Semiconductor Division, 930 Pitner Ave., Evanston, Ill.

BLOCKING-OSCILLATOR FREQUENCY DIVIDER PRODUCES 2-MILE TO 50-MILE RADAR MARKERS

The series-triggered blocking oscillator shown previously (*I&A*, June 1958) can be adapted to become a pulse-frequency divider as shown in this circuit, which is NBS-BuAer Preferred Circuit PC50. Tubes used are 5814A twin triodes (12AU7 equivalents).

In frequency-division, the recovery-time characteristic of the blocking oscillator is used to advantage. After a blocking oscillator has been triggered, its grid voltage is highly negative because of the charge left on the grid capacitor. A trigger input received before this capacitor discharges has no effect. As the discharge time of the capacitor depends on the resistance in series with it, by proper choice of resistances the blocking oscillator can be made to respond only to every other pulse, or to every third, fourth or fifth pulse. Higher division ratios than five are possible, but operation is not considered sufficiently stable for reliable operation in military equipment.

Input to this circuit is a train of positive pulses spaced 12.2-usec apart. As 12.2 usec is the time for a radar pulse to travel 1 mile and back, these pulses are known as "one-mile markers." The first blocking oscillator of the chain can be adjusted (with its 250K-ohm potentiometer) to divide by 2, 3, 4 or 5. Hence its output, at point A, consists of 2-, 3-, 4-, or 5-mile markers, which can be used in a radar indicator as distance marks.

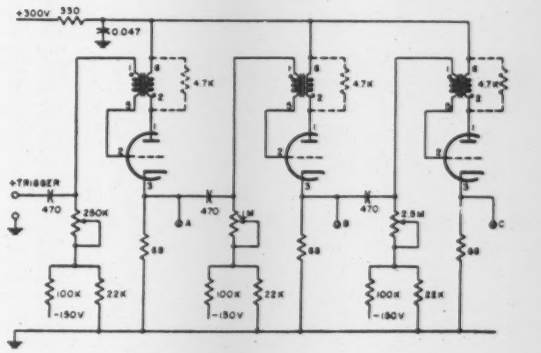
The second divider has a division ratio of 5, providing 10-, 15-, 20-, or 25-mile markers at point B. Similarly, 20-, 30-, 40-, or 50-mile markers are available at the output of the third divider, which divides by 2.

Grid time-constant potentiometers of the second and third divider stages are made larger (1 megohm and 2.5 megohm) than in the first divider stage as the time between the input triggers to these stages is greater. Adjustment of the grid time-constant is required to make up for tube and transformer differences; after initial adjustment, the potentiometer need not be changed until a tube is replaced.

Time-constant potentiometers are readily adjusted by using an oscilloscope to check the division ratio. Each potentiometer should be set to the mid-point of the division range; for example, for division by 5, it should be set half way between the position for division by 4 and the position for division by 6.

Circuit will operate stably for variations in input trigger amplitude of ±10% from the nominal level of 30v, and simultaneous variations of ±10% in heater, bias, and plate power supplies. When only plate supply voltage was varied, a stage dividing by 5 remained stable for plate supply voltages from 200-500 v.

Input trigger must be obtained from a cathode follower or other low-impedance source so that the division ratio is not affected. Maximum trigger source impedance is specified at 400 ohms. As in the preceding circuit, appreciable current is drawn from the trigger source when the first-stage blocking oscillator fires.



Additional blocking-oscillator divider stages can be cascaded to obtain higher division. Of course, the grid-circuit time-constant must be increased for stages having longer periods. Larger capacitors (up to 1500 uuf) are used to limit total resistance required.

Input: Positive triggers, 30 v ±10% amplitude, 0.13-usec max. rise time.

Source impedance: 400 ohms max.

Duty cycle: 0.05 max.

Output: Positive pulses, 30 v amplitude.

Output rise time: 0.05 to 0.25 usec, depending on transformer.

Output pulse width: 0.5 to 1.5 usec, depending on transformer.

Output impedance: 68 ohms (approx.)

Pulse delay: 0.25 usec per stage.

Source: NavAer 16-1-519, *Handbook of Preferred Circuits, Navy Aeronautical Electronic Equipment*, National Bureau of Standards, Washington, D. C.

Journal of the S C M A . . .

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Capacitance Level Instrumentation

A discussion of the basic probe factors, circuits used, and applications of capacitance level-measuring instrumentation.

C. R. CARKEEK & J. W. PHILIPPE
Robertshaw-Fulton Controls Company

CAPACITANCE is the property of two or more bodies which enables them to store electrical energy in an electrostatic field between the bodies. Two of the most widely used formulas for calculation of capacitance are:

1. For parallel plates:

$$C = 0.22KA/d$$

where C is capacitance in micromicrofarads ($\mu\mu$f); A is area of the plates, in square inches; d is distance between plates, in inches; and K is dielectric constant of material between plates.

2. Concentric shielded (a rod within a cylinder):

$$C = 0.614\ KL/\log_{10}(b/a)$$

where C is capacitance in micromicrofarads; K is dielectric constant of material between plates; L is length of cylinder; b is inner diameter of outer electrode; a is outer diameter of inner electrode.

The probes or electrodes that are used as the primary elements of capacitance-actuated instruments are, in a sense, variable capacitors. The capacitance of a probe changes, usually, as a result of a change in dielectric constant. Capacitance values for several materials and different vessels are listed in Table 1.

TABLE 1—CAPACITANCE BETWEEN PROBE AND TANKS FILLED WITH VARIOUS FLUIDS

Vessel Diameter	Dielectric Constant	Capacitance
60"	(Air) 1	3 $\mu\mu$f/foot
60"	(Oil) 3	8 $\mu\mu$f/foot
60"	(Water) 80	55 $\mu\mu$f/foot
11/16"	(Air) 1	15 $\mu\mu$f/foot
11/16"	(Oil) 3	33.5 $\mu\mu$f/foot

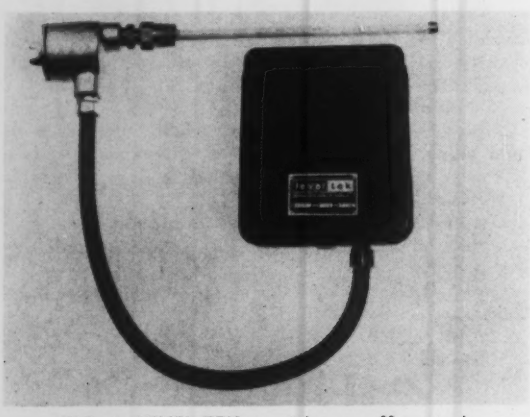

FIG. 1. LEVEL-TEK provides on-off control.

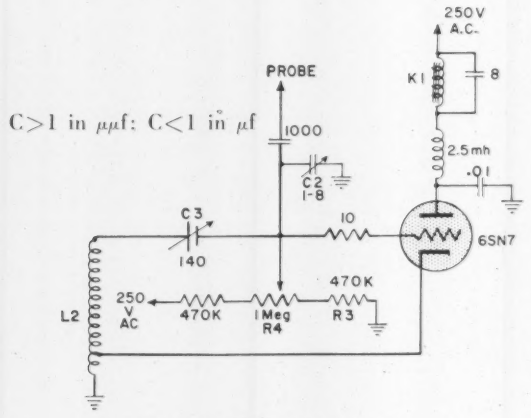

FIG. 2. LEVEL-TEK detector circuit.

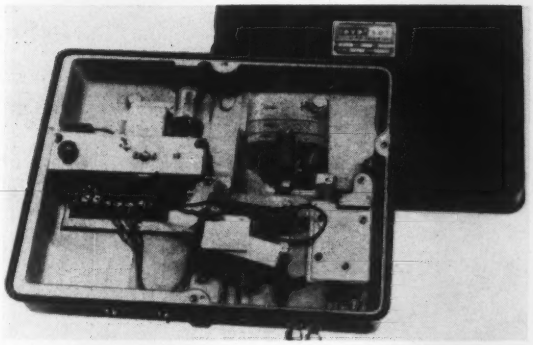

FIG. 3. LEVEL-SET provides proportional pneumatic control.

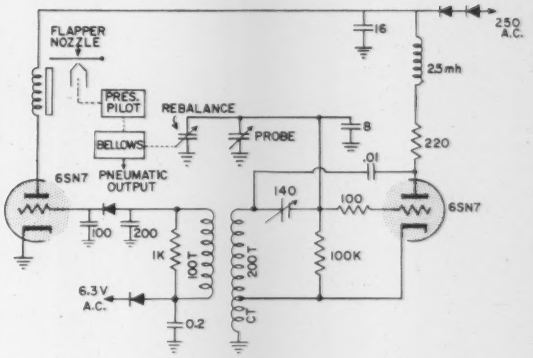

FIG. 4. LEVEL-SET circuit.

Various circuits are available for translating these capacitance changes into on-off control signals (Level-Tek), proportional pneumatic signals (Level-Set), proportional electric signals (Level-Tel), and combinations (Level-Log).

Level-Tek Electric On-Off Control

Level-Tek (Fig. 1) provides *off-on* control. The electronic circuit (Fig. 2) is a modified Hartley oscillator designed so that it will stop or start oscillating as the probe capacitance is changed. The probe is electrically part of the oscillator circuit.

When level in the vessel is at its lowest point a variable capacitor (on the front of the electronic chassis) is adjusted until the relationship between this capacitor and the probe (also a capacitor) will sustain radio-frequency oscillations. As long as the circuit oscillates, electrons are attracted to the grid when the grid swings positive with respect to the cathode. These electrons are collected on the coarse sensitivity control (C3). The leakage of these electrons through resistors R4 and R3 develops a negative bias on the grid. This bias limits the plate current to a low value so that relay K1 is not energized. This is the situation that exists when the level within the vessel is low (low probe capacitance).

When the level in the vessel is raised and the probe is covered, probe capacitance is increased and the circuit no longer oscillates. The grid bias now becomes less negative, permitting more plate current to flow, with the result that relay K1 is energized.

The B supply is 250 v ac, taken from a transformer. Capacitor C2 is a vernier sensitivity control.

All resistors are $\frac{1}{2}$ watt.

Probe: change in capacitance is from 3 to 50 $\mu\mu$f per foot of probe, depending on tank size, dielectric, etc.

September Meeting: Thursday, the 17th, Rio Hondo Country Club, Downey, Calif.

Feature: J. M. Lang of So. Calif. Gas Co. will discuss Plug Valve Actuators; H. W. Newsome will discuss Gas Flow with Positive Displ. Meters.

Level-Set Pneumatic Unit

Level-Set (Fig. 3) is a capacitance-actuated system that provides a pneumatic signal proportional to a change in level. The Level-Set instrument uses the same basic Hartley oscillator as the Level-Tek (Fig. 4); however, the circuit always oscillates and provides a proportional pneumatic signal.

When level increases, the increase in probe capacitance causes an increase in current through the oscillating tank inductor. This increase is rectified to produce a grid signal for the triode shown at left, which has a solenoid in its plate circuit. The increase in current pulls the nozzle-flapper closer to the nozzle so that a greater air pressure is reflected to the pilot relay valve. This increased air pressure is fed to the rebalance bellows and to the control valve. The rebalance bellows repositions the rebalance capacitor to a value approximately equal to the original unbalance at the probe, caused by the level change. The same air signal is fed to a control valve, which decreases its valve opening so that a lesser amount of product is fed into the vessel. The control system thus restores the level or reaches a new state of equilibrium.

Level-Tel

Level-Tel (Fig. 5) provides a continuous indication of level through the use of an r-f oscillator, a capacitance-inductance bridge, a voltage-to-dc rectifier, and a d-c milliameter (Fig. 6). Again the basic circuit is the Hartley oscillator, which operates all the time the system is in service.

When the two secondary sections of L1 are equal (Fig. 6) the bridge requires equal values of capacitance on either side of the bridge to achieve a balance. In practice, the zero-adjust capacitor is balanced against the probe and coaxial-cable capacitance when the probe is in an empty tank so that no signal is developed across the output. After the initial zero-adjustments have been made, the system is ready for full-scale calibration.

However, in practice it is possible that the two secondary coils are not equal. If this is the case, it is

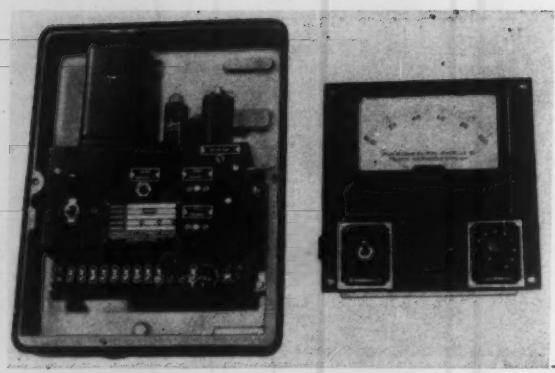

FIG. 5. LEVEL-TEL.

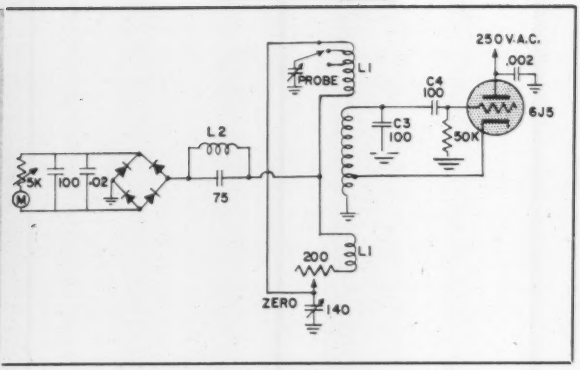

FIG. 6. LEVEL-TEL circuit.

necessary to change this ratio when the vessel is filled if full-scale condition does not provide a full-scale meter deflection. The zero calibration will affect the full-scale calibration, and vice versa, so it is important that some method of checking the zero calibration be provided after the tank is filled, other than forcing the customer to empty his tank. Provisions have been made so this check can be made, via a standardizing switch and procedure (not shown).

Capacitor C4 is required for excessive cable lengths and probe capacity. It has a value of about total probe and cable capacity minus 75 $\mu\mu$f.

Frequency: Long probes operate best at 100 kc to ½ Mc; short probes at ½ to 1 Mc.

Level-Log with Pneumatic or Electric Control

Level-Log (Fig. 7) provides continuous indication or record with pneumatic or electric control. The r-f bridge chassis is similar to that of the Level-Tel, comprising oscillator, bridge measuring circuit and demodulator bridge. After modulation of the 500-kc r-f signal with 60 cps, the modulated signal is fed to the bridge, consisting of the probe, coaxial cable, the zero-adjust capacitor, compensating coaxial cable, the rebalance capacitor, and the zero-set capacitor (Fig. 8). Any unbalance in the bridge due to changes in the probe capacitance results in a phase shift. The demodulated bridge signal is amplified and fed to a servomotor (Fig. 9) that rebalances the rebalance capacitor a proportional amount and direction to offset the probe unbalance.

The servomotor that is used to actuate the rebalance capacitor is mechanically connected to the instrument pen or to pneumatic or electric controls.

Process Application Considerations

Dielectric constants for most hydrocarbons range from 2 to 3, while that for alcohols and glycols range from 10 to 30. All aqueous solutions exhibit high dielectric constants—that for water is approximately 80. Mica has a dielectric constant of 6 to 8 and is consequently an excellent dielectric for capacitors because it can produce a capacitance change 6 to 8 times larger than the same size capacitor with air as dielectric.

The frequency of the alternating current across the capacitance bridge usually is in the order of 100 kc to 1 Mc. The capacitance of most process probes is of the order of 10 to 100 uuf; thus frequencies of 100 kc to ½ Mc permit much larger signal currents to flow than

FIG. 7. LEVEL-LOG.

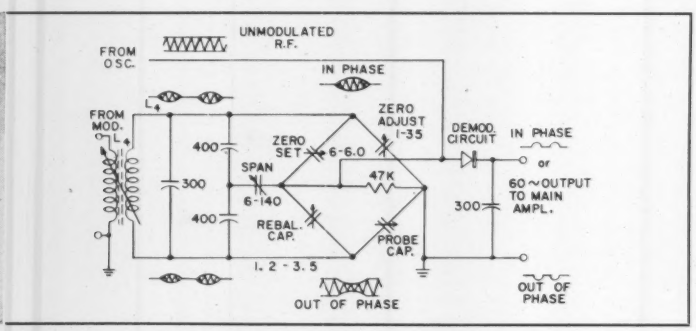

FIG. 8. LEVEL-LOG capacitance bridge circuit with demodulator.

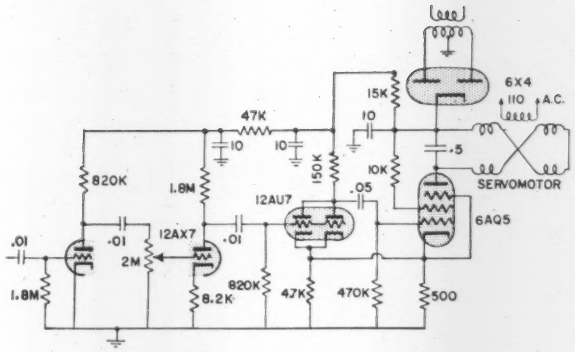

FIG. 8. LEVEL-LOG servomotor circuit.

would flow in the same bridge energized with a 60 to 400 cps alternating current.

The rule-of-thumb for probe selection is to size the probe to develop a capacitance change at least 5 times greater than the sensitivity of the instrument, to assure good stable control.

Applications

Capacitance applications can be classified in a number of ways. One general classification could be (1) variable-distance applications (2) variable-area applications, and (3) variable-dielectric applications. Proximity applications will be discussed as variable-distance and variable-area applications, and liquid and solid levels with fixed probes will be discussed as variable-dielectric applications.

A. Proximity Applications

A simple proximity probe is a large horizontal disc suspended by a vertical insulated conductor. The capacitance of such a probe increases as a conducting liquid rises toward it. The set point determines the distance of the control level from the disc probe. These probes can be sized to give effective control of non-conducting low-dielectric materials, such as an organic adhesive. This type of probe is used by several large soap and detergent manufacturers for continuously controlling the level in surge vessels of viscous liquid soap.

An example of variable-area proximity control is found in the automotive industry. A belt conveys doors to an assembly station where a horizontal disc probe monitors the end of the conveyor belt. Whenever a steel door moves under the horizontal disc, the increase in capacitance stops the conveyor belt until the door is removed.

B. Variable-dielectric Applications

Variable-dielectric applications can be subdivided into non-conducting liquids, conducting liquids, emulsions, interface problems, and solid powders and granules.

1. *Non-Conducting Liquids*

Liquid level of organic liquids such as naptha, gasoline, hydrocarbons, alcohols, etc., are examples of non-conducting liquid applications. High- and low-level alarms and controls on Bunker C fuel oil tanks are successful. These applications use 12″ to 18″ probes mounted horizontally or vertically in the fuel tank. Continuous indication of fuel tank levels and throttling control in surge tanks also is practical.

2. *Conducting Liquids*

Aqueous solutions have dielectric constants in the order of 50 to 80 and are conducting. These liquids produce large capacitance changes on insulated probes and are usually easy control problems.

The capacitance probe often finds application in foaming liquids as a high-level foam detector. Many of the applications in conducting liquids are easily accomplished by conductivity control, but occasionally a conducting-liquid application can be accomplished with a capacitance instrument even when conductivity instruments fail. For example, a layer of oil occasionally accumulates on top of liquid ammonia in refrigeration receivers. The oil can coat a conductivity probe and insulate it from the liquid ammonia, thus giving a low-level signal. A thin layer of insulating oil has little or no effect on the change in capacitance due to the rising level of ammonia in the receiver.

3. *Emulsions*

The continuous phase of an emulsion determines the class of applications problems that the instrument engineer must solve. For example, if the continuous phase is a conducting liquid, then the capacitance instrument will behave as if the conducting liquid were not an emulsion. Consequently, on-off horizontal probe systems would detect the top of the emulsion if the continuous phase is a conducting heavy liquid.

4. *Interface Control*

Interface control usually is an easy capacitance-instrument problem because a significant difference in dielectric constants usually exists between immiscible liquids. For example, the interface control between hexane and methanol is easy because the hexane layer has a dielectric constant of 2.5, while the heavier methanol liquid has a dielectric constant of 22.5. Thus a relatively large capacitance change occurs as the interface moves along the capacitance probe. The capacitance probe finds application in the oil separators of boiler systems because the dielectric constant of oil is 2 to 3, while water is 80. Frequently, the specific gravity difference between the two layers is negligible, yet control by capacitance probe is easy because of the large dielectric-constant difference.

5. *Powders and Granular Solids*

Static pressure changes make no difference to the capacitance probe, which is affected only by changes in dielectric constant. Consequently, capacitance is the ideal system for level control in a pneumatic conveyor system. It also is used frequently to detect plugging of pneumatic transfer lines because a plugged line results in dense phase powder around the probe, which produces a significant capacitance change in the system.

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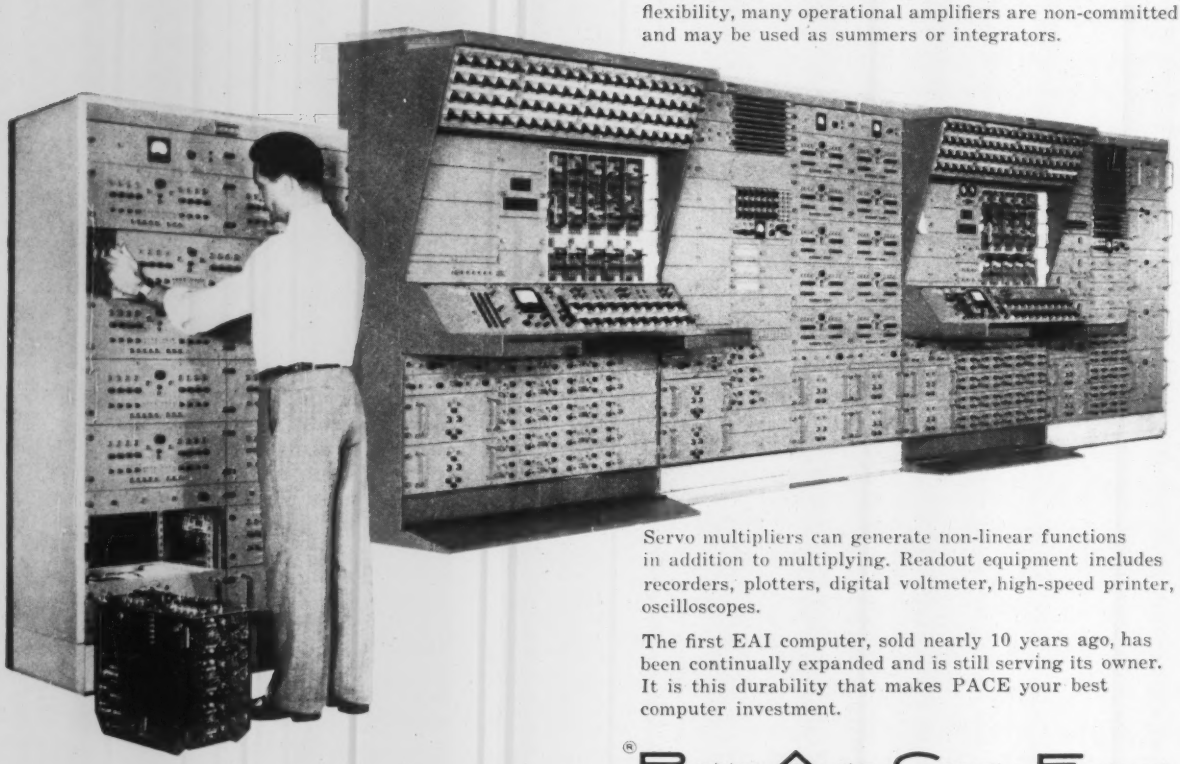

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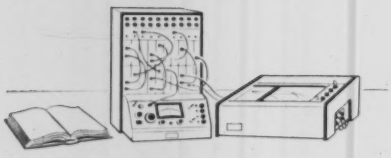

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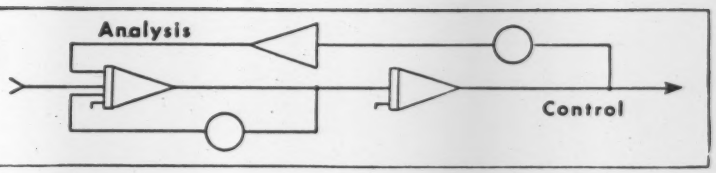

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Bits

This month's *Newsletter* is based largely on info supplied by *Sidney Korn* (Sylvania Electronic Systems, Waltham, Mass.), Secretary-treasurer of the Eastern Simulation Council. It concerns their meeting of February 16th at Grumman Aircraft (Bethpage, N.Y.) and their meeting on April 20th at the Sperry-Piedmont Division of Sperry-Rand (Charlottesville, Va.).

At the February meeting *E. J. Kennelly* told of the "Development of a Multi-purpose Research Simulator" (reported last month). *E. Mishkin* presented a paper "On Some Computer Problems in Adaptive Control Systems." *Frank Richmond* discussed "Trends in Simulation." *T. J. Haggerty* described the simulation equipment in the Grumman Avionic Engineering Lab. and *C. E. Fischer* spoke on the use of a manned centrifuge for simulating the flight of the X-15.

At the April meeting the following papers were presented: "Simulation of Radar-Guided Missile at Low Altitudes by Use of a Low-angle Simulator" by *W. S. Thompson*; "Automatic Trajectory Plotting for Molecular Beam" by *O. R. Harris* and *Jaime de la Quintana*; "Application of DC Analog Computing to a Stagewise Extraction Problem," *O. L. Updike* and *Patricio Castro*; "Generating Non-linear Functions in Analog Computers with Thyrite Varistors", *Leroy U. C. Kelling*; "Precision Generator for Time-Varying Functions", *G. F. Emch* and *J. F. Bradshaw*; "Ocean Wave Simulation", *V. E. Williams* and *T. Nobel*.

Brief abstracts of the April talks (and a fuller treatment of the Emch paper) are given under **PIECES**, while an abstract of another paper which your Ed. found interesting, "Pulsed Analog Computer* for Simulation of Aircraft" by *A. W. Herzog* is given under **INFO**.

Pieces

EASTERN S/C MEETING OF FEB 16 ON RESEARCH SIMULATOR, ADAPTIVE SYSTEMS, TRENDS, AND X-15

The Eastern Simulation Council held its meeting of 16 February 1959 at Grumman Aircraft (Bethpage, N. Y.); 74 members attended. Dr. *C. E. Mack*, Chief of Research, welcomed the group on behalf of Grumman after a tour of the simulation facility.

Gerald D. Fogel, Head of the Analog Computing Section at Grumman and chairman of the meeting, called first on *E. J. Kennelly* of the Research Department (Grumman). His paper, "Development of a Multi-purpose Research Simulator" was reported in some detail in the July issue of the *Newsletter*.

Professor *E. Mishkin* (Microwave Research Institute of the Polytechnic Institute of Brooklyn, N. Y.) next presented a paper on his recent work "On Some Computer Problems in Adaptive Control Systems."

Professor Mishkin pointed out that many problems arise in the process control field in which the transfer function of the process is not only unknown but is time-varying; only the desired output is known. He then described the characteristics required of a controller for such a process and analytically derived the controller coefficients, which were in the form of the convolution integral

$$C_k = \int_0^t f(t)\, g_k(t-\tau)\, d\tau$$

where g_k is the impulse response of the system.

Sidney Korn, who as Secretary of the ESC supplied the notes on this meeting, did not report Professor Mishkin's talk in detail. We understand it is to appear in the *Proceedings of the IRE*.

Frank Richmond (Glenn Martin Co., Baltimore, Md.) next spoke on "Trends in Simulation."*

T. J. Haggerty (Avionic Staff Engineer, Grumman) presented an outline of simulation components of the

*Some may say that because the system operates on discrete pulses it is not analog; others will say that because the information is contained in the amplitude of the pulses, it is. I say whatsit?!—Ed.

*This topic (a popular one!) was the subject of the May meeting of the Western Simulation Council this year and the June meeting of the Eastern SC. We've decided to combine all of this "where do we think we're going" info (including Frank's talk) in one future *Newsletter*.

Avionic Engineering Laboratory, now under construction. Sorry, but we have no details.

The last speaker at the meeting, Commander *C. E. Fischer* (NADC, Aero Computation Lab., Johnsville, Pa.), discussed the use of a manned centrifuge flight simulator for measuring acceleration effects associated with the X-15. The forces acting on a body in a centrifuge were described by a vector diagram, and the analytical expressions describing the operation of the centrifuge derived.

The centrifuge control system can be either externally directed or controlled by the man in the centrifuge gondola in simulated flight. When directed externally, a function generator provides the desired commands.

Commander Fischer also showed a film on a simulated flight of the X-15.

EASTERN S/C MEETING OF APRIL 20 ON "COMPUTERS IN ANALYSIS AND CONTROL"

The Eastern Simulation Council meeting on "Computers in Analysis and Control" was held at the Sperry-Piedmont Division of Sperry-Rand Corporation in Charlottesville, Virginia on 20 April 1959.

We present here abstracts of five of the talks as prepared for us by *Sid Korn*, plus one complete paper as prepared by the authors.

Simulation of Radar-guided Missile at Low Altitudes by use of a Low-angle Simulator

W. S Thompson
Applied Physics Laboratory
Johns Hopkins University

A real-time simulator for simulating the reflected energy that radar-guided missiles receive when flying at low altitudes has been designed and constructed by the Ordnance Research Laboratory at the University of Virginia, and is now in operation at APL. A reflected carrier wave, simulated by a 25-kc signal, is amplitude modulated by a sea model and an antenna pattern, while simultaneously a 25-kc direct carrier wave is frequency modulated by an antenna pattern. The resulting signals are summed, filtered of the 25-kc signal, and phase-compared to provide the apparent error input to the missile computer which is simulated on the DC analog computer.

The flight geometry, also programmed on the computer, provides continuous calculation of the direct and reflected pointing errors, the doppler difference frequency, and the grazing angle of the reflected ray which, along with the target maneuvers, are the inputs to the simulator.

Preliminary studies on a position-feedback beam rider missile flying a low-angle programmed beam indicates comparable results with those experienced in actual flight tests.

Automatic Trajectory Plotting for a Molecular Beam

O. R. Harris and
Jaime de la Quintana
University of Virginia

A conducting-sheet analog has been combined with a DC operational analog to trace the paths of ammonia molecules in a MASER. The focusing fields are represented by electrodes on the conductive paper. A four-electrode probe picks off the gradient in two dimensions and delivers signals to the computer, whose output positions the probe and simultaneously plots the path.

Application of DC Analog Computing to a Stagewise Extraction Problem

O. L. Updike and Patricio Castro
University of Virginia

The set of algebraic equations representing equilibria and material balances in a multistage extraction cascade have been mechanized on a general-purpose analog computer. Though the computation proceeds step by step, it is fast enough and accurate enough to have advantages over present graphical methods in selected cases. With more equipment, further mechanization is possible.

Generating Non-Linear Functions in Analog Computers with Thyrite Varistors

Leroy U. C. Kelling
General Electric Specialty Controls
(Waynesboro, Va.)

Exact simulation on analog computers requires that all non-linearities and saturation limits of the actual system be represented in the circuits of the computer. Only an exact simulation will respond to all inputs in a manner identical to that of the real system. Normally, this has been accomplished only by the use of many expensive function generators. However, many non-linear functions and saturation limits can be economically obtained by using Thyrite varisters in the usual analog computing circuits.

Some of the silicon carbide, Thyrite varistors are manufactured with characteristics of voltage and resistance which are adaptable to the usual analog-computer circuits. These varisters can be used in place of, or connected in parallel or series with, the fixed or adjustable computing resistors to produce a wide variety of non-linear functions. The best procedure for obtaining a desirable non-linearity is a cut-and-try process during which the input-output characteristics are observed on the X and Y axes respectively of an oscilloscope. Several representative circuits and typical varistor characteristic data were described.

Precision Generator for Time-Varying Functions

G. F. Emch
J. F. Bradshaw
Applied Physics Laboratory
Johns Hopkins University

An analog technique has been recently developed at APL/JHU for the generation of time-varying functions. Mr. Emch explained that in the past they have generated this type of function by such conventional methods as diode function generators, tapped pots, photo-followers, or plotting-board curve followers.

None of these approaches to the problem was particularly satisfactory The first two methods are limited in that the function must be approximated by a finite number of line segments. The photo-follower is not noted for its stability and, where accuracy is required, a photo-slide of the function to be generated is necessary. The plotting-board curve follower is limited by the speed of response of the plotter and its ability to track the curve being followed. All these methods require involved and time-consuming setup procedures, and with many of them it is not easy to change the function being generated.

In the early fall of 1957 they hit upon the idea of using a punched-paper-tape teletype reader as a precision function generator for their

SPEAKING WITH EASE®

An up-to-the-minute report on computer technology prepared by the **Beckman/Berkeley** *engineering staff*

Diode Function Generators: A Comparison of Types

As we attempt to simulate physical phenomena with greater detail and precision, we find that nature is far less regular than the inquiring mind desires. Our integrators, summers and multipliers fail to create analogs of many unruly variables, and we must turn to the diode function generator for a close approximation of empirical fact. Of the many types of DFG's available none is optimally designed for all purposes. The prospective user must decide which characteristics are most important to him and be content with necessary limitations in other respects. Foremost considerations are faithful simulation, ease and speed of set-up and cost. Let's see how available DFG's compare.

Differences in Curve-Fitting Ability

The precision with which a DFG can approximate a function depends primarily on the number of diode breakpoints and on the ability to position breakpoints where most needed, that is, at X values where the change of slope is greatest. DFG's can be ranked from best (most breakpoints, freely movable on X axis) to worst (fewest breakpoints, at fixed intervals on the X axis). One should exercise caution in applying this rule however, because a large number of diode breakpoints may give rise to other sources of error. This happens because the more diodes conducting simultaneously, the greater phase shift, drift and noise. In newer models this difficulty is overcome by designing circuits so that only those diodes in one quadrant conduct at any given time.

Differences in Set-Up Time

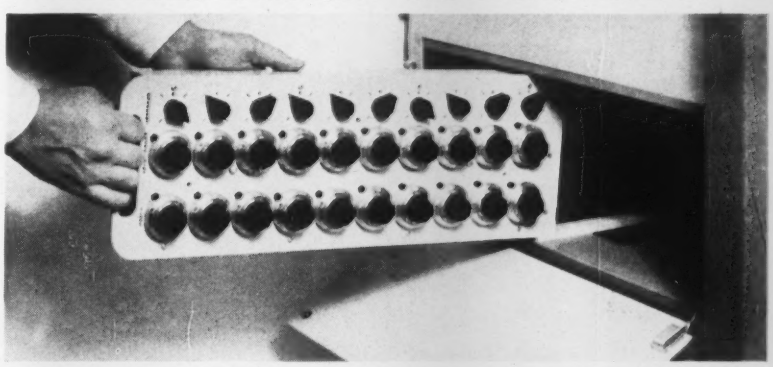
The card-set DFG offers instantaneous set-up once the function has been coded. Holes punched in the card actuate relays which connect resistances into the diode circuit to create desired slopes. Disadvantages are fairly high cost, difficulty in fitting many curves because breakpoints are located at fixed intervals along the X axis, and a possibility of uncorrected errors because the operator cannot easily detect an error in coding. Nevertheless, the rapid switching of functions can be very useful.

The automatic tape-set DFG provides rapid set-up along with greater accuracy and flexibility. One fully automatic model can be set-up from a typewriter or even a digital computer. Drawbacks lie in the great expense of tape logic equipment plus the fact that the initial set-up is difficult to check and requires careful programming.

Semi-automatic DFG's have all the advantages of fully automatic except that initial set-up, being manual, is more time-consuming. An advantage of manual set-up – not to be underrated – is that the operator can easily check the function for errors. Necessary tape logic equipment is much less expensive, though the installation still requires a digital entry system such as the DO/IT.

Pushbutton-set DFG's offer the same accuracy and curve-fitting abilities as semi-automatic models at far lower cost. Functions can be set-up fairly quickly (each breakpoint can be set with pushbuttons in a few seconds), but re-entering a function requires the same labor as an initial entry.

The DFG with manually set potentiometers is still a standby in analog computation. Its high accuracy, low cost and ability to generate varied functions have made it a favorite where lengthy set-up procedures can be tolerated. The slow set-up, its principal disadvantage, has been overcome in the recent EASE model pictured below by mounting potentiometers separately on plug-in modules which permit function change with the speed of card-set models. Costs rise with the number of spare potentiometer modules desired, but expense remains far less than the cost of automatic or semi-automatic DFG's.



The new EASE Model 1177 diode function generator and its mounting unit. Four plug-in function generators are contained in 8¾ inches of rack space. For flexibility, each DFG channel contains ten breakpoints and uses standard inverting amplifiers from the computer. Breakpoints can be located in any quadrant, and high input impedance allows paralleling of several channels. Write for specifications.

C7

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Bendix G-15

PUNCHED CARD AND TABULATOR COUPLER

...a new accessory for the Bendix G-15 Digital Computer for low cost, high performance punched card computing

Now, at a cost significantly below that of any similar equipment, Bendix provides a complete computing system with 100 card per minute punched card input and output, and 100 line per minute tabulation.

Heart of the system is the Bendix G-15 general purpose digital computer, which has proven its performance in well over 150 successful installations.

The CA-2 coupler, a newly developed G-15 accessory, enables the computer to operate in conjunction with conventional punched card and tabulating equipment.

A full 80 columns of numeric, alphabetic, or special character information can be accommodated using only the CA-2 as a connecting link between the card equipment and the G-15. Any column of the card can contain any one of the three types of information.

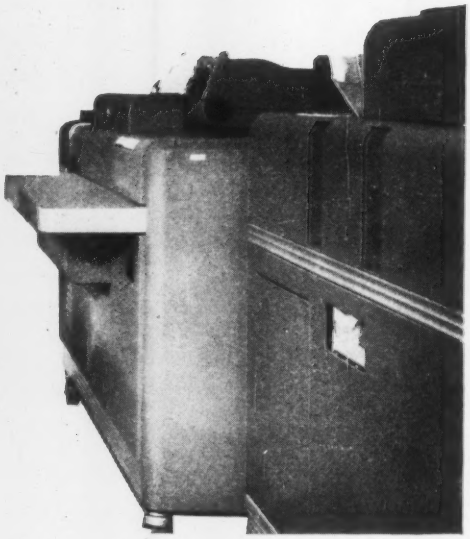
Three input-output units may be connected simultaneously . . . one for input, one for output, and a third for input or output. Data may be read or punched by standard card units, or printed by standard tabulators. All input and output is under complete control of the computer. Computation can proceed during the input or output cycle, thus assuring maximum over-all computing speed.

In addition to the CA-2, the computer's typewriter and paper tape equipment, and auxiliary magnetic tape storage units may be used for completely versatile input, output, and storage. Both power and space requirements of the complete punched card computer system are approximately half that of other systems of this type.

A system that includes the G-15 computer, the CA-2 coupler, two summary punches and a tabulator, leases for approximately half the price of a typical medium-priced system with similar capabilities.

Whether you are now using punched card or computing equipment, or if you are delaying such plans due to high costs, you will want to learn more about this inexpensive, efficient equipment. Detailed technical information on the G-15 and the CA-2 will be sent on request. Write to the Bendix Computer Division of Bendix Aviation Corporation, Los Angeles 45, California. Dept. J-11.

Bendix Computer



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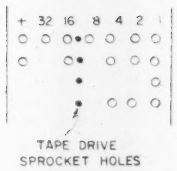


Fig. 1. Meaning of tape hole position.

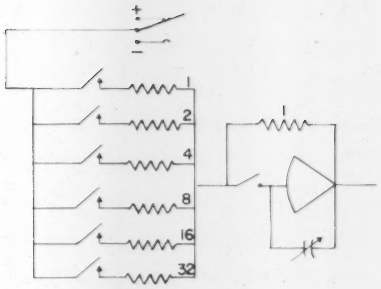


Fig. 2. Tape reader contacts.

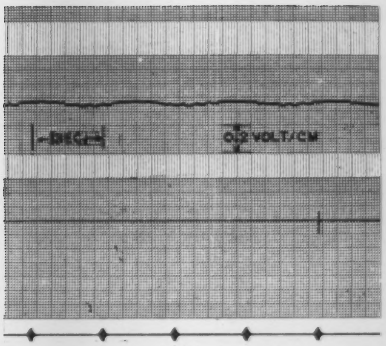


Fig. 3. Tape-generated 10-v signal.

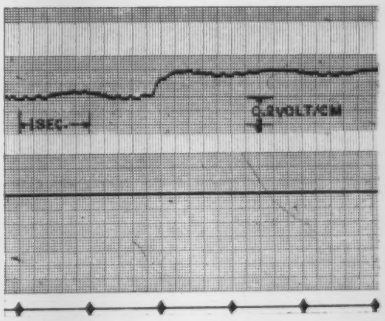


Fig. 4. Tape-generated step voltage.

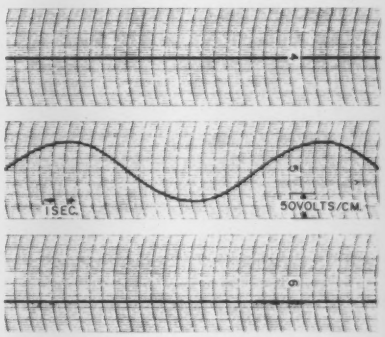


Fig. 5. Tape-generated sine wave.

analog computer. Since that time they have heard that such a device was employed in Germany during World War II and, more recently, by workers at Bell Telephone Labs.

The generator consists of a digital storage medium (punched tape), a memory interrogation unit (the tape reader), a digital-to-analog converter (resistor matrix), and smoothing circuits. The tape reader detects holes in the tape by means of a line of feelers which are allowed to rest against the tape during part of the tape feed cycle. Whenever a hole appears opposite a feeler, the feeler is allowed to extend through the tape and momentarily close a switch. In their adaptation of the device Emch and Bradshaw have assigned one hole position to indicate the desired sign of the output. The remaining six holes are assigned binary weights and are used to create the desired magnitude of the output signal (Fig. 1).

The outputs from the feeler-controlled switches are fed through an appropriate gain network and combined in a holding network as shown in Fig. 2.

The circuit shown provides a relatively smooth output with a minimum of equipment. The combination of smoothing and holding in one amplifier proves much more advantageous than any other approach Emch and Bradshaw have seen. The holding circuit in particular makes the smoothing problem much simpler by preventing the signal from returning to zero during the open time of the switches. The trace shown in Fig. 3 was obtained by comparing a constant ten-volt signal with the generator output obtained from a tape punched to produce a constant ten-volt signal. The maximum deviation is less than 30 millivolts. There is an 0.769-cps oscillation on the trace; this resulted from the beating of the 5-cps tape sampling rate with a 60-cps hum in the breadboard circuit. Proper packaging of the circuit should remove this difficulty.

As an example of circuit performance for a non-constant input, Fig. 4 is shown. The recorded function was a stairstep with a step approximately every four seconds. This type of function was chosen to show the error occurring at the step due to the effect of the holding-circuit time constant. This response can be increased by reducing the time constant, thus providing higher accuracies at the step.

The accuracy of fit of the function generated is, of course, primarily influenced by the minimum amplitude increment and the sampling rate. At low frequencies, compared to the tape cycling rate, the generator can track the function to within a percentage of the peak value of the function given by:

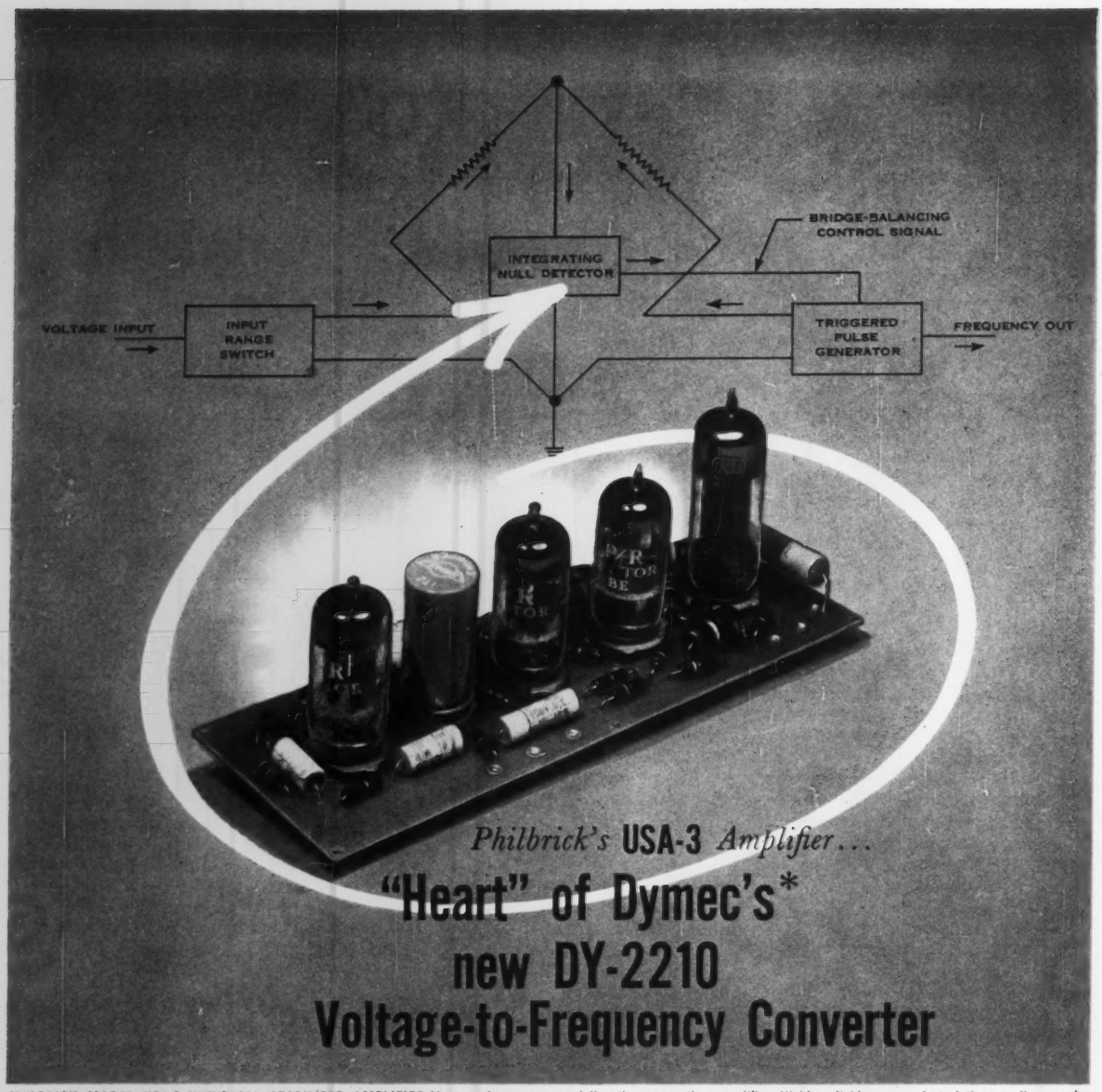
$$\left(\frac{100}{2^{n-1}-1}\right)\%$$

where n is the number of holes (or bits) which can be read per tape sample. (One of the holes is used to provide sign information).

Thus a seven-hole tape reader can resolve a function within 1:587% of its peak value, while a twelve-hole reader will have a maximum capability of 0.0975% of peak. Frequency limitations are defined by Shannon's sampling theorem, which in essence states that the functional frequency may not exceed $\frac{1}{2\Delta t}$, where Δt is the time step. This however is the optimum condition, and in practical application is unattainable because of the holding-circuit time constant. Theoretically, a function of frequencies greater than 2.5 cps could not be produced with the 5-cps reader available. In practice, errors become excessive for functions with frequency components greater than 1 cps.

Maximum magnitude errors occur at the point of maximum slope of the function, assuming of course that this slope continues monotonically throughout Δt. Let $y = f(t)$. With $\dot{y}$ and $\ddot{y}$ existing, then setting $\ddot{y} = 0$, there exists some (t_1) which satisfies $\ddot{y} = 0$ such that the maximum slope occurs at this point t_1. Substitute t_1 in $\dot{y}(t)$ such that $\dot{y}(t_1) = M$, where M will be this maximum slope at this point. But over this particular time step Δt, $M = \Delta y / \Delta t$, which implies that the maximum $\Delta y = M\Delta t$.

The sine wave is shown in Fig. 5. This function can be produced quite accurately by a short trial-and-error approach. That is, it is evident that the exact values cannot be punched on the tape because of the effects of the time constant in the holding cir-



Philbrick's **USA-3** *Amplifier...*

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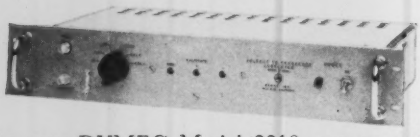
PHILBRICK MODEL USA-3 UNIVERSAL STABILIZED AMPLIFIER-More performance per dollar than any other amplifier. Highly reliable — no electrolytic capacitors or glow tubes. Designed to prevent self destruction even when output is grounded. Drift, noise, offset under 100 microvolts. Output, 116 vdc.Wide frequency range — dc to 100 kc (attenuation less than 3 db) when connected as gain-of-ten amplifier. Printed circuit board, 7" x 2½", mounts by several convenient methods. **PRICE $95**



The new DYMEC Model 2210 compares the area under a stable, calibrated pulse train with the average value of an input signal and continuously adjusts the pulse rate for equality. The result: a pulse frequency proportional to input voltage within 0.1% of full scale up to 10 kc.

The summing integrator performing this comparison must have very high reliability and low drift while maintaining low distortion. Furthermore, it must be sufficiently economical to make this product feasible at its low price of $650.

Only Philbrick's Model USA-3 Universal Stabilized Amplifier met all these exacting needs.

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The analog way is the model way ..... GEORGE A. **PHILBRICK** RESEARCHES, INC.

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* dy *DYMEC, INC. Palo Alto, California*

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cuit. However, changes can be made easily and rapidly after the results of the first tape are recorded. They have found that usually the second tape can produce accuracies on the order of 0.2% full scale. To eliminate such cut-and-try procedures Emch and Bradshaw are preparing correction curves for use with the tapes.

The device has proved to be very dependable. Since the summing amplifier and input dividers are both quite stable, the function generator is very stable, and gives results which are precise. Tapes can be changed in a matter of seconds and are easily stored. Inexperienced personnel can easily and quickly punch new tapes. As a matter of fact, the tapes could be automatically prepared by digital computers like APL's Univac 1103A.

Emch and Bradshaw feel that their present unit is by no means the ultimate in digital function generators. If additional amplitude resolution is required, they can get up to a twelve-hole tape reader ($\pm$ 2047 units), or if a higher frequency response is called for, photoelectric tape readers are available with reading rates on the order of 200 steps per second.

Ocean Wave Simulation

V. E. Williams
T. Nobel
Sperry Piedmont (Charlottesville)

Since man first hollowed out logs and set himself asail, he has had the urge to know what makes the ocean churn and, more directly, to know what effect this churning will have upon himself.

Now, with a time series approach and the use of analog and digital computers, man might be able to bring the churning ocean—minus the ill effects that go with this churning—into his laboratory.

This paper concerned itself with a possible approach to the simulation of the ocean and the use of this simulation in studying effects of ocean waves upon boat motions.

Information (Without Theory)

Your Ed's happening to spot the short (three pages plus five figures) article in the imposing (651 pages) Part 1 of the May *Proceedings of the IRE* must be attributed to serendipity, as his first reaction upon receiving the mighty tome was to put it aside until he had time to give it the attention it seemed to demand (i.e., never open it!)

However, "Pulsed Analog Computer for Simulation of Aircraft" by *A. W. Herzog* (U.S. Naval Training Device Center, Port Washington, N.Y.) suggests, explicitly and implicitly, ideas which are different—to say the least.

There has been a lot written, in this *Newsletter* and elsewhere, on combined analog-digital systems. However, most if not all such systems have clearly analog and clearly digital subsystems with converters between them to change the form of the information.

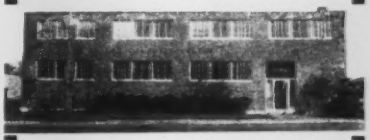
The Herzog design calls for a "magnetic drum to perform the functions of storing the program and the aerodynamic data required in the computation. Time-shared analog computing elements encompassing the normal arithmetic operations of addition, subtraction, multiplication and division are used. They are connected to a common bus through gating circuits. In addition, electronic integrators (one for each integration required) and analog-storage elements are provided. Utilizing these elements sequently, it is possible to complete a computation cycle in each revolution of the drum. Function generation is accomplished in this computer by means of specialized circuitry which determines the position of the four surrounding break points of a given value of a function of two or more variables. The discrete values of the function at the break points are selected from digital drum storage for an interpolation procedure. A type of 'floating point' system is included to scale automatically all voltages to fall within optimum levels for the operating elements."

Here we have digital and nominally analog components operating together in one system. True, there is a decoder for d-a conversion and an encoder for a-d conversion, but as all

GPS

Statistical Analog Computer gives you an advantage of 2500 to 1.*

Computing at a rate 3000 times faster than real time, **a random process is completely analyzed in minutes of time.**



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The GPS computer is a new and significantly different device. It is not merely a new twist, nor a new automation of an old idea. Statistical problems need no longer: be over simplified, require lengthy programming, use expensive machines, or be placed on the shelf.

Every engineer concerned with systems engineering should investigate the applicability of the GPS Statistical Analog Computer.

* See page 1221, July '58 Issue of Instruments & Automation.

For full details call or write Dept. 20

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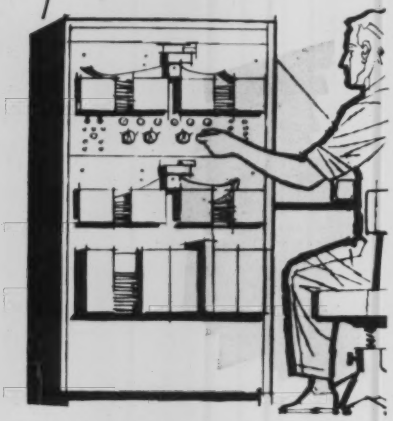

Tape Preparation & Editing Console

It makes error-free paper tape

By automatically verifying and/or duplicating paper tapes. The console consists of a numerical keyboard, two punch tape readers and one tape perforator. The buffer storage system uses unique Tally Logic Switches.

It features...

Tape to tape duplication and verification at 60 characters per second
- Keyboard visual display and shift register to eliminate copying errors and operator fatigue in both punching and verifying modes
- Tape corrections without over punching or splicing.

It's ready for delivery now

For complete technical information, prices, delivery, and the name of your nearest Tally engineering representative who will be happy to arrange for a demonstration, please address Dept. 558.

TALLY
REGISTER CORPORATION
5300 14th Avenue N.W., Seattle 7, Wash.

See this Console and other tape handling equipment at WESCON, Booth 119.

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SIMULATION COUNCIL

input information comes from the drum memory, the "analog" output of the decoder is in the form of a voltage which can only assume discrete values directly related to the digital input. The information contained in the pulses thus is not continuously variable, and is therefore not analog. As this information is operated by the analog computing elements, the number of discrete voltage levels is undoubtedly increased until their identity is lost in the noise, but theoretically the information is still quantized. The physical limitations on its recovery may be thought of as comparable to the loss of information in a digital computer which results from roundoff.

However, the question of whether this is a digital or a hybrid computer is purely academic*; we shall be much more interested in the practical aspects of its performance.

* * *

Seems that their new advertising agents are determined that we shall not forget our old friends at Computer Systems, Inc. (née Mid-Century). They now tell us they have an AM-FM multiplier with dynamic accuracy of ±0.05% full scale at 500 cps. We of course do not question their numbers, but bet a lot of readers will want to know how they made the measurements!

* * *

Speaking of friends of long standing, have you noticed EAI is offering "The *First* All-Transistorized Analog Computer," a desk-top basic model for less than $4,000?

* * *

And there is another new (to us, anyway) entrant into the field. Electro Precision Corp., Arkadelphia, Arkansas, is offering their "Collegiate", portable model with chopper-stabilized amplifiers.

* * *

Excerpt from a letter by *Alfred Cotcher* (Cubic Corp., San Diego, Calif.), editor of the San Diego *IRE Bulletin*, replying to your Ed's request for a back issue of said *Bulletin*:

"I have available several sworn witnesses who will testify that yesterday was one of feverish activity in my office. For example, the following tremendous task was conceived, initiated, carried forward, and completed within the confines of that single earth-shaking day. A substantial accumulation of old IRE Bulletins, dating back to 1955, was sorted and bound, and all duplicates except those of the current (July 1959) issue were thrown out. Your letter, the first request for a back issue since Lindbergh swam the Channel, arrived (naturally enough) this morning . . . I immediately alerted the FBI, which is making a thorough search of every dump between here and the El Cortez . ."

*Anyone remember how long ago it was that we said that the whole question of analog or digital was purely academic; that if one looks closely enough, the distinguishing characteristics of analog and digital systems become less distinguishing, and that the question of analog or digital will eventually disappear when some day the two become completely indistinguishable.

He Went Thataway! (Up)

George Beggs, to Executive Vice President and member of the Board of Directors of Leeds & Northrup. George may be best known to computer people for the influence he wielded in connection with his company's entrance into the simulation field with their atomic reactor simulator, and into the computer field by way of their cooperation with Philco in the development of an industrial process controller.

Computer Events

Central Simulation Council

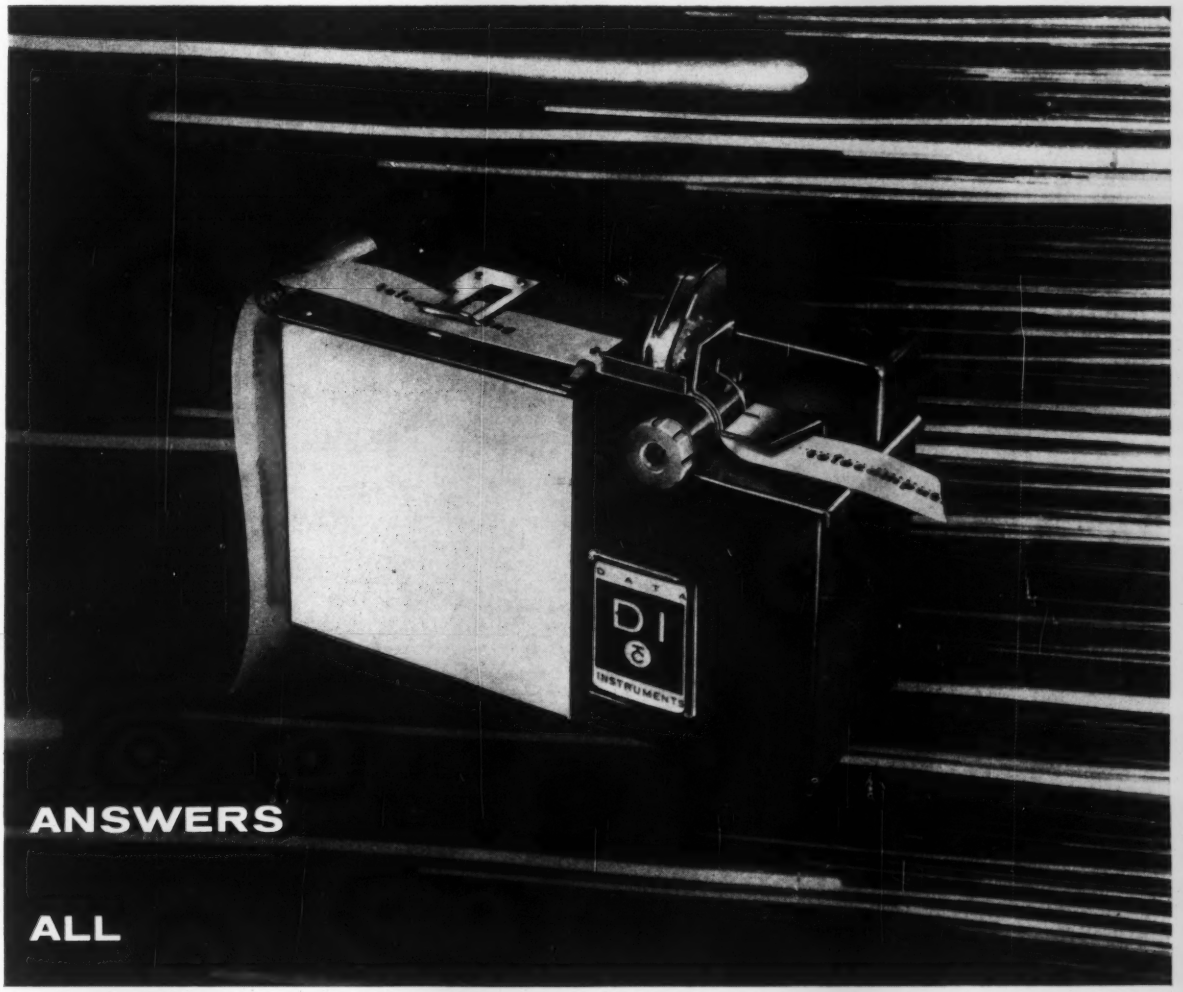
Date: October 1959
Place: McDonnell Aircraft Co., St. Louis, Missouri
Subject: "Computer Environment"

Instrument Society of America 14th Annual Instrument-Automation Conference and Exhibit

Dates: 21-25 September 1959
Place: Conference will be held in the Palmer House, Chicago: Exhibit in the International Amphitheatre, 46th and Halstead Streets, Chicago

Theme will be "World Progress in Instrumentation", with presentations from the Netherlands, France, Sweden, Germany, Russia, Czechoslovakia, and Japan.

Inquiries should be addressed to ISA, 313 Sixth Ave., Pittsburgh 22, Penna.



ANSWERS ALL PAPER-TAPE PUNCHING REQUIREMENTS

THE *NEW* DATA INSTRUMENTS HIGH-SPEED TAPE PERFORATOR

Here is the one that outperforms them all! This new, high-speed, moderate cost Tape Perforator accepts any tape width or code level up to 1 inch 8 channels — even up to 30 channels on request...with a punching speed of 40 columns per second! Incorporates a simplified drive mechanism with minimum mechanical motions for high-speed operation, long life. These and many other unique design features of the Data Instruments Tape Perforator make it the ideal choice of *all* paper-tape punching in the fields of data handling, data reduction, data processing, and business systems. Write, wire, or phone for complete information.

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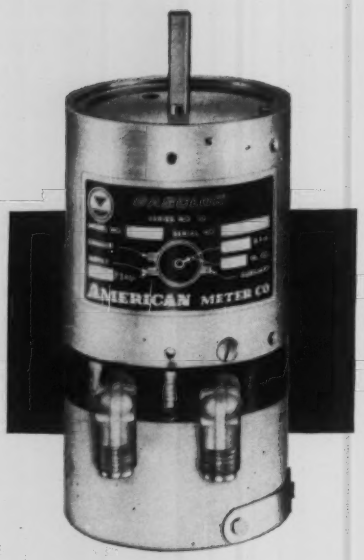
CIRCLE 82 ON READER-SERVICE CARD



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GASCLOK

POWER DRIVE

Completely self-contained gas or air-powered instrument driving and timing unit for long, trouble-free operation in remote locations. The GASCLOK delivers more than 20 times the torque of conventional spring-wound mechanisms. Continuous timing accuracy is unaffected by a ± 20% variation in supply pressure.

Inherently explosion proof and self-starting, the GASCLOK is ideal as original or replacement equipment for strip chart and conventional circular chart instruments. The timing mechanism is internally sealed to prevent corrosion, and all power unit parts exposed to gas are aluminum or stainless steel. Large area internal ports prevent clogging. Normal air or gas consumption 5 cfh . . . operating pressure 5 psi . . . rotation 2 rpm.

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CIRCLE 83 ON READER-SERVICE CARD

new instruments

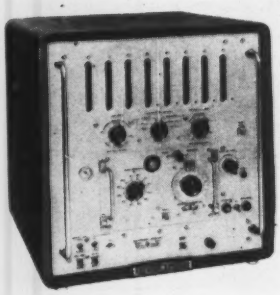
FOR FURTHER INFORMATION USE THE FREE ORDER CARD ON PAGE 1241

MINIATURE SOLENOID VALVES

New line of miniature, small-ported, two-way Series 90, and three-way Series 95, direct-acting Solenoid Valves with brass or stainless steel bodies, features a-c shading coils of fine silver and fully rotatable coil housings for electrical connections from any angle. Orifice sizes for Series 90 range from 1/32" to 1/8". Series 95 has orifice sizes from 1/32" to 1/6". Two-way types are available in normally-open and normally-closed designs; three-way types also include a universal flow pattern. —*Hoke, Incorporated, 31 Piermont Rd., Cresskill, N. J.*

CIRCLE 201 ON READER-SERVICE CARD

ELECTRONIC COUNTER

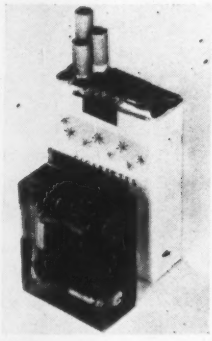


New Electronic Counter, Model 524D, featuring a uniform 8-decade numerical readout, has a crystal-oscillator stability of 3 parts in 10^8 short-term; 5 parts in 10^8 per week. It provides for full frequency measurements from 10 cps to 10 Mc and period measurements from 0 cps to 10 kc. A plug-in provides for time measurements from 1 μsec to 100 days. Time is measured in 0.1-msec, 1 msec, 10-msec, or 10-sec increments, with total registration of 99,999,999 counts.—*Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.*

CIRCLE 202 ON READER-SERVICE CARD

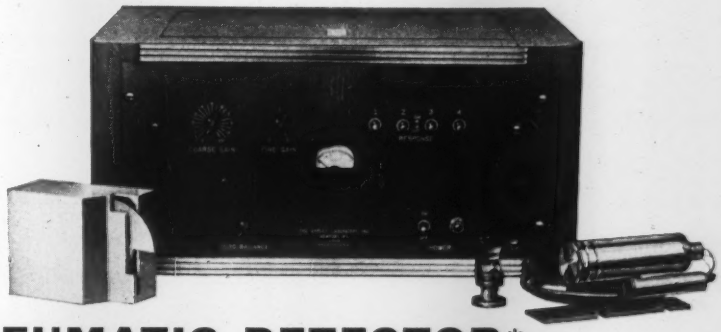
LIQUID LEVEL CONTROL

New Liquid Level Sensor with Delta C Module, is especially suited for cryogenic level control but also for industrial applications. Heart of the sensor is the Delta C Transistor Module (mounted directly in the head of the probe) which furnishes certain knowledge that gas is in its liquified rather than its gaseous state during a loading operation. Probes are made in three basic designs: shielded, non-shielded, and flush, and the probes are inert to almost all reagents.—*Trimount Instrument Co., 3119 West Lake St., Chicago 12, Ill.*



CIRCLE 203 ON READER-SERVICE CARD

A Superior Detector for Infra-Red Spectroscopy



GOLAY PNEUMATIC DETECTOR*

Among the characteristics that render the Golay Detector superior to other types of detectors for use in infra-red spectroscopy are:

1. **An effective sensitive area 3/32" in diameter.**
2. **Sensitivity of 6 x 10-11 watts RMS-ENI when used with "chopped beam" method and with recording time constant of 1.6 second.**
3. **Uniform sensitivity from the ultra-violet through the visible and the entire infra-red, and up to the micro-wave region.**
4. **Improved, drift-free, A. C. operated amplifier with step gain controls and four response periods.**

Write for EPLAB Bulletin No. 10

*Fundamental and experimental aspects of this detector are discussed in the following publications: Rev. Sci. Inst. *18*, 347 and 357 ('47); ibid. *20*, 816 ('49); Proc. IRE *40*, 1161 ('52).

278-8

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SCIENTIFIC INSTRUMENTS
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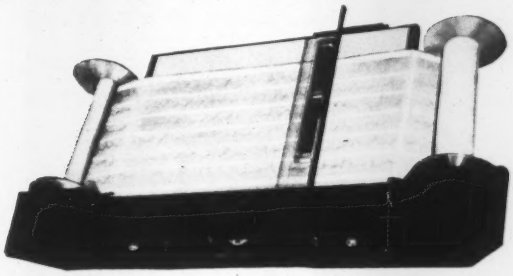
CIRCLE 84 ON READER-SERVICE CARD

GERBER PRESENTS –

AN OSCILLOGRAM SCANNER THAT TRACKS YOUR RECORD!



This Free Trial Offer Proves It!

From extensive testing, we know that you must be satisfied with this scanner. We are so confident it will work for you that we ask you to specify 7 day free trial on your purchase order.

Order now—or write for full details.

$595.00
FOR 12" MODEL.

$625.00
FOR 16" MODEL.

$95.00 extra for Variable Scale with mounting attachment.
F.O.B. Hartford, Conn.
Terms: Net 30 days.

GENERAL SPECIFICATIONS

- RECORD WIDTH—0 to 12", 0 to 16".
- RECORD SPEED—0 to 100 ft. per minute.
- TOP—Fully illuminated 24" long surface.
- CONTROLS—On or off, forward and reverse, variable record speed.
- RESPONSE—Instant positive braking.
- RECORD CORE INSIDE DIAMETER—1/8". Any longer core diameter can be built up with a false core enlarger.
- MAXIMUM ROLL DIAMETER—6".
- LOADING—Cantilever bars—no paper threading required.
- CURSOR—12" or 16" long.

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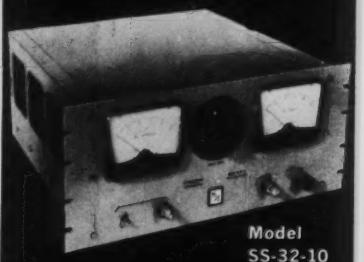
liability!

In NJE Solid State Transistorized Power Supplies every component is the highest quality military or commercial type available (example: every transformer and choke is a MIL T-27A style unit, every resistor is wire-wound). All are significantly derated under the most severe combination of line, load and ambient conditions. Proven reliability makes NJE your best Power Supply buy! 14 standard models cover virtually every job. Here's one:



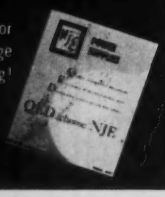
Model SS-32-10

Output, volts: 0-36.
Output, amps: 0-10.
RMS ripple: 1 millivolt.
Regulation, load: ±0.015% or ±1 MV.
Regulation, line: ±0.03% or ±2 MV.
Internal Impedance DC-20KC: 0.04 ohms.

PRICE: $750

FOB Kenilworth, N. J.

Write today for this new 16-page Power Supply catalog!



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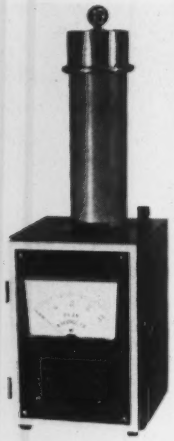
CIRCLE 86 ON READER-SERVICE CARD

PORTABLE PEAK VOLTMETER

New Series-8520 Hypot Portable Voltmeter directly measures positive and negative voltage peaks to 150 kv,

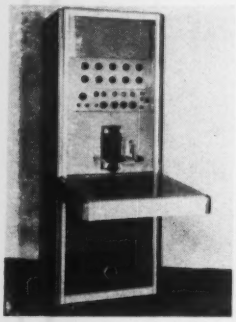


and d-c as well as rms-potentials to 115 kv across high-voltage circuits without the losses and inaccuracies that may be introduced when measurements are made in the primary circuits.—*Associated Research, Inc., 3777 W. Belmont Ave., Chicago 18, Ill.*

CIRCLE 204 ON READER-SERVICE CARD

COMPUTER-MODULES TESTER

New Logic-Module Tester automatically measures speed and degree of response as well as continuity of logic circuitry printed on a card. Up



to nine different basic tests or test programs may be performed on each of the module circuits, and up to 50 tests can be performed with any or all of the 9 programs, making a total of 450 test decisions per module.—*Atronic Products, Inc., One Bala Ave., Bala-Cynwyd, Penna.*

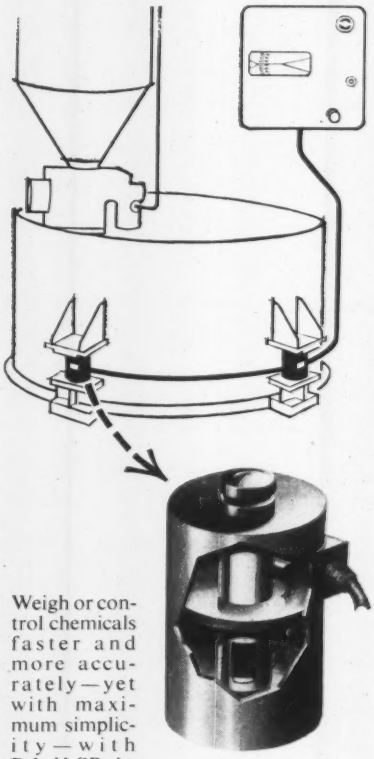
CIRCLE 205 ON READER-SERVICE CARD

PROPORTIONING PUMP

New plunger-type, small-capacity Proportioning Pump, Model 1107 Adjust-O-Feeder, provides low-cost injection of boiler-treatment chemicals in boilers used in hospitals, schools, industrial plants, etc. Features in-

MEASURING QUANTITY?

Then do it the modern way ... with accurate, rugged, trouble-free SR-4® Load Cells



Weigh or control chemicals faster and more accurately—yet with maximum simplicity—with B-L-H SR-4® Load Cells. Installed as part of the tank support structure, no part of the measuring system comes in contact with the contents of the tank. Can be installed on tanks already in use. Output suitable for use with local or remote indicator, recorder or automatic dispensing control. Explosion-proof. Hermetically sealed—unaffected by dust, grease or moisture; long service life assured. Available in standard capacities of 50 through 200,000 lb., accuracies to ±0.10%.

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SR-4® Strain Gages • Transducers • Testing Machines

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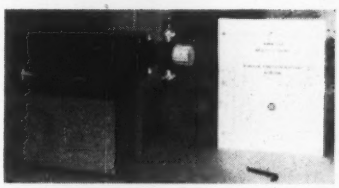
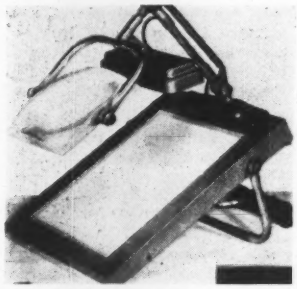


clude adjustable stroke length to give feed rates of from 0.2 to 2 gph into 300-psig maximum discharge pressure. —*B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R. I.*

CIRCLE 206 ON READER-SERVICE CARD

VIEWING TABLE

New 8½" x 11" Viewing Table, with a 6" x 6" optically-ground magnifying lens and independently-

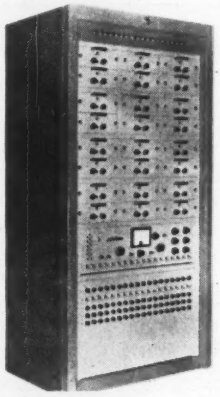


controlled overhead fluorescent lighting (110 vac), magnifies and illuminates top and/or bottom for retouching, viewing, critical inspection, x-ray, graphic arts, microfilm, etc.— *Burke and James, Inc., 321 S. Wabash Ave., Chicago 4, Ill.*

CIRCLE 207 ON READER-SERVICE CARD

ELECTRONIC MULTIPLIER

New AM/FM Electronic Multiplier, Model MC-701, provides four-quadrant multiplication of input variables



at frequencies in excess of those feasible by other methods. Noise level is less than 30 mv; drift less than 50 mv per 8 hours. Input impedance is greater than 1 megohm; output inpedance is approximately 0.05 ohm. —*Computer Systems, Inc., 611 Broadway, New York 12, N. Y.*

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ONE MAN CONTROL

G-A *Cushioned* Flowtrol Valve

It's easier to operate a G-A Flowtrol Valve than it is to drive a car with power steering! The reason? Line pressure furnishes the power to open or close the valve. No manual effort, no handwheels, no motors, no levers are needed —regardless of size of valve or pressure. Just a "flick of the wrist" or press of a button will fully open or tightly close the valve.

Get all the facts in Bulletins W-8A and G-4.

GOLDEN ANDERSON *Valve Specialty Company*

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Designers and Manufacturers of VALVES FOR AUTOMATION

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Glass Tubes and Rods for Scientific Use—Lamps, Furniture, Lighting & Decorative Fixtures—Display Domes—Contract Cutters of Tube and Rod.

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INSTRUMENT
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GAS ANALYSIS INSTRUMENTS

Continuous and Portable units

✓ **CHROMATOGRAPHIC ANALYZERS**

Complete systems for laboratory and process stream analysis—control.
CHROMA-CAT series extends utility of analysis, allows use of AIR as carrier gas.

✓ **ELECTRO-CONDUCTIVITY ANALYSIS**

Continuous measuring for PART PER MILLION toxic gases in work areas; impurity control in process streams. Applicable on any gases (or gas combustion products) which ionize in water.

✓ **COMBUSTIBLE GAS ANALYZERS**

REMOTE HEAD and multi-point systems for detection of combustible gases and vapors in work areas; Litho and coating oven atmosphere control; etc. Control of combustibles in inert gas streams.

✓ **THERMAL CONDUCTIVITY ANALYZERS**

MEASUREMENT of concentration of one gas component in a mixture of gases utilizing sensitive T/C filaments as the detector. Applicable for determination of: H_2 in $O_2 \cdot N_2$ mixtures; Argon in Air; Hydrogen purity; CO_2 in flue gas, etc.

Write for Descriptive Literature

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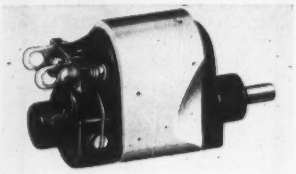
CIRCLE 90 ON READER-SERVICE CARD

NEW INSTRUMENTS—CONTINUED

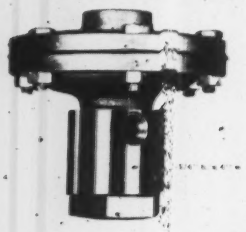
MINIATURE D-C MOTORS

New Open-Frame Type 820 permanent-magnet D-C Motors have high starting torque at operating speeds upwards of 20,000 rpm, with operating d-c voltages between 3 and 30 v. Locked-rotor (maximum) torque is approximately 0.5 in-oz, with working torques in the range of 0.4 to 0.1 in-oz.—*Cramer Controls Corp., Centerbrook, Conn.*



CIRCLE 209 ON READER-SERVICE CARD

BLOCK AND VENT VALVE

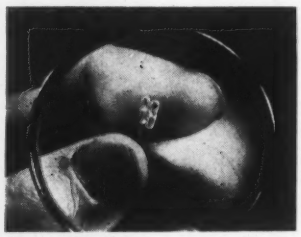


New ¼" Block and Vent Valve features straight-through air flow at operator pressures of 5.5 psi or greater. As the operator pressure drops to 3.5 psi, air service is blocked, and when it reaches 2 psi or less, the cavity between the blocked ports is vented to atmosphere.—*George W. Dahl Co., Inc., 86 Tupelo St., Bristol, R. I.*

CIRCLE 210 ON READER-SERVICE CARD

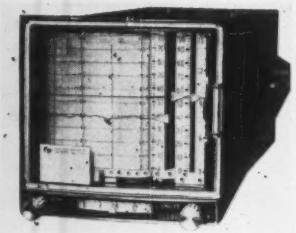
THERMISTOR PROBES

New Thermistor Probes with identical resistance/temperature characteristics (therefore interchangeable) eliminate the need for individual calibrating. Presently two standard probes are offered with this feature. Absolute resistance of each probe is given in 1°F increments from 0°F to 350°F. Resistance changes from 26,520 ohms at 0°F to 70.4 ohms at 350°F indicate the great sensitivity obtainable.—*Fenwal Electronics, Inc., 51 Mellen St., Framingham, Mass.*



CIRCLE 211 ON READER-SERVICE CARD

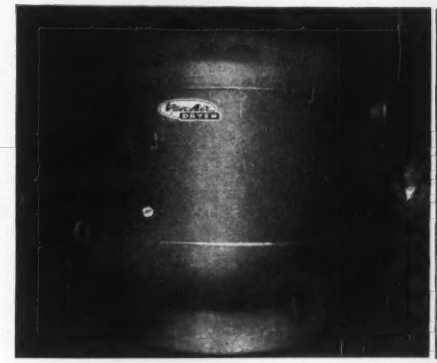
STRIP CHART RECORDERS

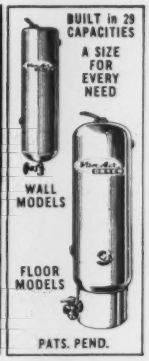


New four-inch Strip Chart Recorder and Recorder Controller (Mark III line), feature a modified inking system (that provides a full month's record without refill), a flip switch (for reversing controller action from air-to-open to air-to-close), wide-visibility plastic door, built-in damping of pneumatic input signals, fused chart motor, and bold easy-to-read scales with large high-intensity-colored pointers.—*Fischer & Porter Co., 143 Jacksonville Rd., Hatboro, Penna.*

CIRCLE 212 ON READER-SERVICE CARD

FOR MORE INFORMATION ON PRODUCTS REPORTED OR ADVERTISED, CIRCLE CORRESPONDING NUMBER ON READER-SERVICE CARD ON PAGE 1241. IF THE CARD HAS ALREADY BEEN USED, MARK NUMBER AND DATE OF ISSUE ON POSTAL CARD AND SEND C/O OUR READER SERVICE DEPT.





VAN-AIR DRYER (above) DRIES and CLEANS COMPRESSED AIR at rate of 6000-cfm—sufficient for ENTIRE PLANT. 28 other sizes of VAN-AIR Dryers COVER COMPLETE RANGE OF PNEUMATIC OPERATIONS down to 1-cfm.

COMPRESSED AIR DRYERS FOR ALL PLANT OPERATIONS

Equipped with exclusive triple-desiccating chamber, VAN-AIR Dryers extract all water from compressed air—remove foreign particles and gaseous oils—destroy bacteria—reduce moisture below zero F dewpoint—operate WITHOUT heat, power, regeneration, injection or volume loss—perform continuously and automatically at the exceptionally low cost of

LESS THAN 1/16-CENT PER 1000 CU. FT.

At this low rate—under 1% of cost to compress air (national average)—VAN-AIR Dryers prevent freezing, corrosion, contamination, dilution—protect air lines, controls, tools, processes, instruments, chemicals, foods, drugs, spraying, blasting, finishing, packaging, etc. Can be installed outdoors. Will not freeze.

Van-Air DRYER

SEE THE VAN-AIR IN ACTION at I.S.A. SHOW, Booth 673, International Amphitheater, CHICAGO, Sept. 21-25. Send NOW for brochure with charts.

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3 new instruments for process control

MV-1 POTENTIOMETER

For testing, calibrating or servicing newest process controllers and amplifiers which convert millivolt input signals into proportional currents for control or telemetering. Combines all functions of precision potentiometer, millivolt source and milliammeter. 1/10 of 1% accuracy. 5⅜" x 8" x 5⁹⁄₁₆". 5½ lbs.

THE AUTOCOMP 1

For instrument checking and thermocouple measuring. Gives automatic cold junction compensation to devices used for measuring or controlling with thermocouples. Exclusive circuit employs thermistor network to match non-linear characteristics of thermocouples with output characteristics of bridge. 5⅜" x 8" x 5⁹⁄₁₆". 6 lbs.

RU-1 "RUN UP" SOURCE

Combination millivolt and milliampere "run up" source for instrument calibration. Checks newest process controllers and amplifiers. Current source furnished by two self-contained 90V batteries made to give stable, uniform outputs with cold cathode type voltage regulator tube. Self-contained. 5⅜" x 8" x 5⁹⁄₁₆". 10 lbs.

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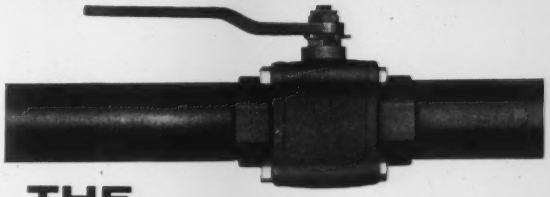
COMPARE



THE ECON-O-MISER BALL VALVE... with conventional GATE VALVES

The **ECON-O-MISER** ball valve provides smooth, round, **two-way flow! Easy to service without removal from the line** . . . half million cycles not unusual . . . acts as both valve and union.

For revealing facts request bulletin EB 101.

WORCESTER
VALVE CO., INC. / WORCESTER 10, MASS.

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A simple, direct reading on the Alnor Velometer gives you an instant measure of air flow speed through grilles, ducts, furnaces, spray booths, or in the open.

Precision-built and self-contained, this portable instrument brings laboratory standards to the line or field installation. Available in a wide variety of scale ranges, full assortment of jets and fittings. You'll want all the facts (no safety department should be without a Velometer). Get Bulletin 2448-G. Attach this ad to your letterhead and mail to: Illinois Testing Laboratories, Inc., Room 518, 420 No. LaSalle St., Chicago 10, Illinois.

PRECISION INSTRUMENTS FOR EVERY INDUSTRY

Alnor

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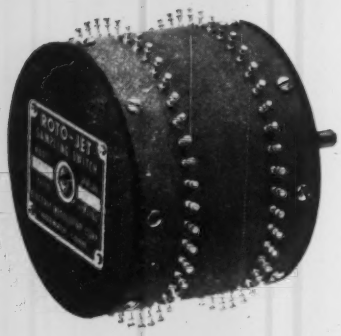
HIGH SPEED SWITCHING



NEW ROTO-JET®

SEQUENTIAL SAMPLING SWITCH MAKES MORE THAN 3,600 CLOSURES / SECOND

No commutator to cause noise and wear! Contacts are closed by a **rotating jet of air!** New self-cleaning ROTO-JET represents the most outstanding development in long life, high speed switching in many years.

At low power levels, signals of 1, 2, and 3 millivolts can be directly transmitted free of measurable noise. Flexible, versatile, **module contact** design enable ROTO-JET to be built with any number of contacts required for a specific application.

Here is the long awaited innovation in high speed sampling and switching where a large number of voltage-generating elements must be connected successively to a single load. ROTO-JET is the perfect solution for **directly** commutating signals from thermocouples; strain gages; light-sensitive devices; and similar low level, high impedance elements employed in computers, telemetering systems, and complex process control. For full details, write for new Bulletin No. 8.030.

Just compare!

ANY SAMPLING SPEED—Sampling or switching speeds up to 40 revolutions per second.

SPLIT-SECOND CONTACT—Closing time less than 60 microseconds; opening time less than 80 microseconds.

2-POLE SWITCHING—Easily supplied to any phase angle.

POSITION INSENSITIVE—Mounts in any position; no effect on precision operation or performance.

NO MAINTENANCE—Wiperless contact design. Routine cleaning of contacts accomplished while switch is operating simply by increasing air pressure for several seconds.

ROTO-JET®

ELECTRIC REGULATOR CORPORATION

Norwalk, Connecticut

Manufacturers of REGOHM® Regulators, MAGOHM® Magnetic Amplifiers, and GOVOHM® Diesel Generator Governors.

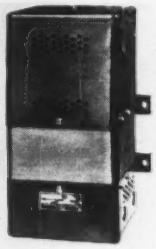
BOOTH 164 CHICAGO

CIRCLE 95 ON READER-SERVICE CARD

NEW INSTRUMENTS

CONSTANT-VOLTAGE TRANSFORMERS

New standard line of Constant Voltage Transformers provides sinusoidal output and ±1% stabilized voltage for line voltage variations of ±15%. In addition to these improved electrical characteristics, the units have been substantially reduced in size and weight for easier handling and installation. Available in nine stock output ratings from 60 va to 7500 va, they are static-magnetic units which have no tubes or moving parts.—*Sola Electric Co., 4633 W. 16th St., Chicago 50, Ill.*



CIRCLE 213 ON READER-SERVICE CARD

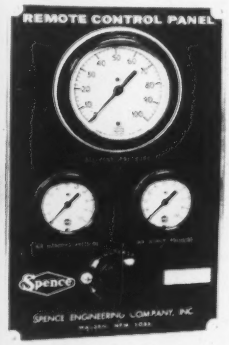
PROCESS RESPONSE ANALYZER

New Model JY 743 Process Response Analyzer for very-low-frequency dynamic analysis has digital output display and integral print-out for feeding an external X-Y plotter with a frequency range of 1.5% of 0.0001 cps to 1 kcps.—4-page data sheet and 2-page preliminary information leaflet give details.—*Solartron, Inc., 530-532 Cooper St., Camden, N. J.*

CIRCLE 214 ON READER-SERVICE CARD

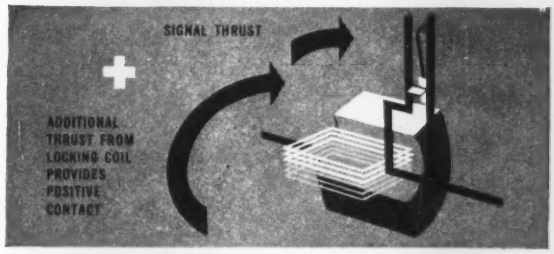
AIR LOADING PANEL

New Air Loading Panel establishing the set point of air-loaded regulators includes gages for delivery pressure, supply air, and adjusting air pressures.—*Spence Engineering Co., Inc., Walden, N. Y.*



CIRCLE 215 ON READER-SERVICE CARD

A.P.I.'S EXCLUSIVE LOCKING-COIL DESIGN

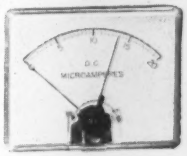


BUILDS A BETTER METER-RELAY

Neatly compact, the A.P.I. Meter-Relay gives you low-cost monitoring and control for any electrically measurable variable. Reliable control, too—on the order of 10,000,000 operations.

The locking-coil design does it. By multiplying many-fold the torque developed in the sensitive D'Arsonval movement, it drives the indicating and set-point contacts together, creating a firm, sure electrical circuit when signal input reaches the set-point level.

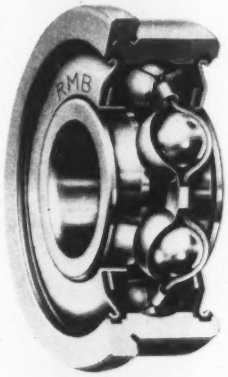
With the A.P.I. meter-relay you can use very small current or voltage inputs; full-scale sensitivity can be as fine as 5-microamperes or 5 millivolts. Without signal amplification, you can control directly from thermocouples, p.e. cells and other sensing elements.



SEND FOR CATALOG 4F.

ASSEMBLY PRODUCTS, INC.
Chesterland 10, Ohio
S.A. 1914

CIRCLE 96 ON READER-SERVICE CARD



NEW!

RMB FLANGED, SEALED MINIATURE BEARINGS AVAILABLE IN ABEC 1, 5, 7 AND THE NEW RMB ULTRA-PRECISE "GYROSCOPE QUALITY" TOLERANCES

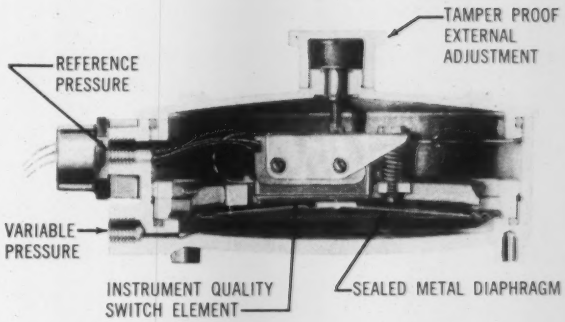
Now available in "Gyroscopic Quality" Tolerances, as well as the more familiar ABEC 1, 5, and 7, new RMB Filmoseal Flanged Bearings offer the engineer the ultimate in preci ion. Sizes range from 0.046" to 0.1875" Bore—0.1562" to 0.375" OD.

RMB RF Filmoseal sealed miniature bearings combine all the advantages of sealed bearings with the rotational freedom of open bearings. Now you can get engineering features in bearings for small mechanisms that you would normally expect in larger-size anti-friction bearings—There is no mechanical contact between rotating and stationary parts—Lubrication is retained and foreign matter excluded by oil encased, non-rubbing capillary seal.

See RMB Super Precision Miniature Bearings at Booth 219 at the Instrument Show, or write to us for full details.

LANDIS & GYR, Inc.
45 West 45th Street, New York 36, New York

CIRCLE 97 ON READER-SERVICE CARD



INSTRUMENT QUALITY DIFFERENTIAL SWITCH

senses pressure differences from .45 to 45 inches of water

Used in hopper level indicating, on oil burner blower safety control, in instrumentation or similar applications where it is necessary to sense a pressure difference of .45 to 45 inches of water between a variable and a reference pressure. The reference pressure may be as high as 30 P.S.I.

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during operating life due to direct acting design	LINKAGES & BEARINGS which, as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements	LIQUID SWITCHING ELEMENTS which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	ACCORDION BELLOWS which make the pressure switch sensitive to vibration.

ASK FOR NEW CATALOG 9-PS FREE

PRESSURE SWITCH DIVISION

Barksdale valves

5125 Alcoa Avenue, Los Angeles 58, California

CIRCLE 98 ON READER-SERVICE CARD

C & S Force Calibrators

With guaranteed direct reading accuracies of 1/20 of 1%, these Cox and Stevens kits set new standards of precision and portability in force and weight measurement. They combine the high accuracy of laboratory equipment with the ruggedness required for field service.

C & S Force Calibrators are designed for on-the-spot, field calibration of testing machines, thrust stands, electronic, hydraulic or lever weighing systems, and can also be used for general purpose, single-point weighing operations. Containing a single load cell, the kits are light, compact and easy to use; available in capacities of 5,000 to 100,000 pounds.

Here are some of the features:

1. High guaranteed accuracy: 0.05% of applied load
2. Fast, direct reading: no conversions or corrections needed
3. 115 V AC operation (24 V DC optional)
4. Compact: All instrumentation, adapters, etc. in one carrying case
5. Portable: Watertight case weighs approximately 50 pounds
6. Easy to use: 50 foot cable plugs into cell
7. Rugged: Multi-column cell has an overload capacity of 225% of rated load

REVERE CORPORATION OF AMERICA

Wallingford, Connecticut

Send for Bulletin 3006 now!

54

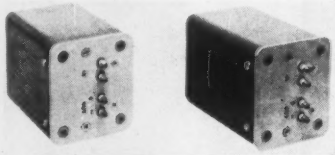
A SUBSIDIARY OF NEPTUNE METER COMPANY

neptune

CIRCLE 99 ON READER-SERVICE CARD

MINIATURE D-C SUPPLIES

New line of miniature, completely-transistorized Regulated d-c Power Supplies operating from 115 vac, 50-60 or 400-cps input comprises 36 mod-

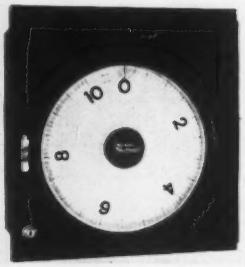


els for each frequency range which covers output voltages, ranging from 3 to 36 vdc in approximately 14% increments, with output power capacities of 2, 4, 8, and 15 w. Voltage regulation is ±0.05% against line and load variations and ripple is less than 0.01%.—*Sorensen & Co., South Norwalk, Conn.*

CIRCLE 216 ON READER-SERVICE CARD

INDICATOR AND CONTROLLER

New electronic Indicators and Indicating Controllers are self-balancing potentiometer and bridge-type instru-

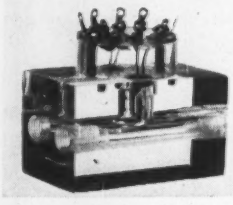


ments featuring a high-gain servo-amplifier that provides stability of ±1 μv and sensitivity of 1μv. Power gain is 315 db and voltage gain is 100,000,000 at rated load.—*Thermo Electric Co., Inc., Saddle Brook, N. J.*

CIRCLE 217 ON READER-SERVICE CARD

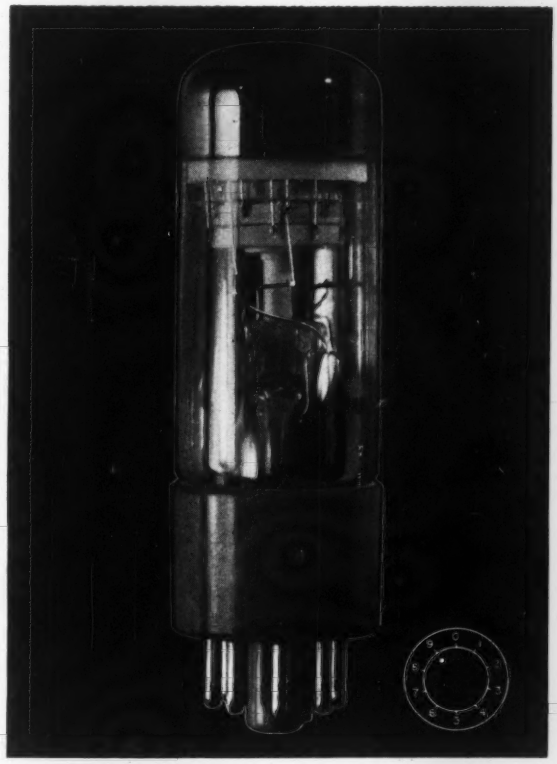
THERMAL CONDUCTIVITY CELLS

New Veco Thermal Conductivity Cells for gas analysis; gas chromatography; and sampling and/or control,



or analysis of chemical processes; contain a matched pair of glass-coated, bead-type thermistors which can be connected into any desired external circuit configuration.—*Victory Engineering Co., 534 Springfield Rd., Union, N. J.*

CIRCLE 218 ON READER-SERVICE CARD



Need a **PROVEN** *tube that indicates and counts?*

dekatron®

The only cold-cathode glow transfer counting tube **WITH OVER 10 YEARS OF SERVICE RELIABILITY AND PERFORMANCE.** Simple circuitry. Electronic speed and accuracy up to 20,000 counts/sec. For counting, sorting, programming, unit flow, packaging and many other applications. Continuous visual reference to total count. For detailed information, request Technical Data Sheet IC4001.

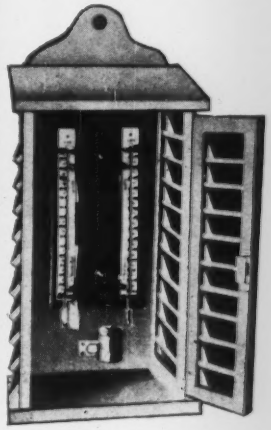
Baird Atomic

Baird-Atomic, Inc.

33 UNIVERSITY RD., CAMBRIDGE 38, MASS.

Instrumentation for Better Analysis

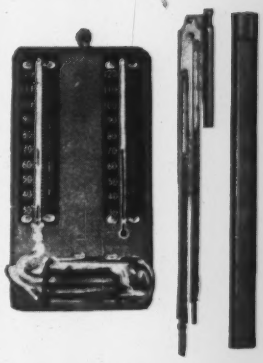
CIRCLE 100 ON READER-SERVICE CARD



True or False?

It's not the heat it's the humidity.

...It's both as measured by MOELLER Psychrometers



These dependable Moeller instruments have received general acceptance for determining relative humidity regardless of climatic conditions. Equipped with two accurate thermometers and easy reading chart. Weather Bureau and Mason's Form, as well as Sling Types, which are available in various ranges and in two sizes, the smaller being the pocket size.

Order your supply of these precision instruments now — Mail the coupon for complete details.

MOELLER INSTRUMENT COMPANY SINCE 1867

132nd ST. and 89th AVE. • RICHMOND HILL 18, N. Y.

Representatives in Principal Cities

Gentlemen: Without obligation, please send me Catalog No. 150 on Moeller Psychrometers.

NAME .....

FIRM .....

ADDRESS .....

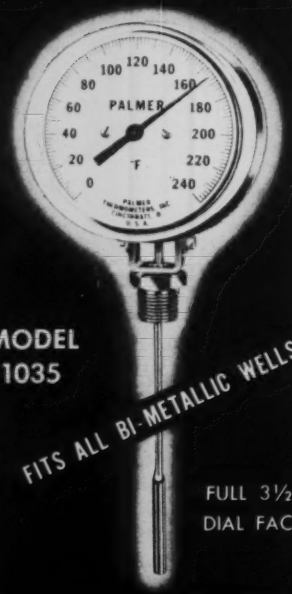
CITY ..... ZONE ..... STATE .....

CIRCLE 101 ON READER-SERVICE CARD

Outstanding Accuracy

PALMER

Dial Thermometer



Check these functional features

- Direct-drive Bourdon Coil with a filled system for longer lasting accuracy.
- Stem can be placed at any desired angle and case can be rotated to most readable position.
- External calibration for zero setting.
- Unaffected by stem alignment.
- Accurate to one scale division.
- No sticking at any temperature.
- Non-corrosive case.

PALMER

THERMOMETERS, INC.

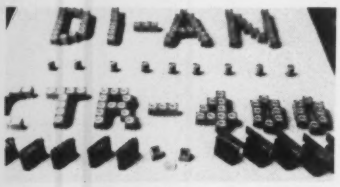
Mfrs. of Industrial Laboratory, Recording and Dial Thermometers

2515 Norwood Ave., Cincinnati 12, O.

CIRCLE 102 ON READER-SERVICE CARD

REGISTER ELEMENTS

New Model CTR-400 Magnetic Shift Register Element (one core per bit) has an output signal with a 50:1 ONE/ZERO ratio. Interlok- Thimble- and Square-package types are stand-



ard. The compatible Shaper-Driver (CTD-400), designed to shift up to 12 register stages at 400 kc, is also available in all standard DI/AN package sizes and to customer requirements. Register elements operate with any rise time on the shift pulse for a pulse width of ¼ to 1 μsec. A width of 0.3 μsec is recommended.—*DI/AN Controls, Inc.*, 40 *Leon St., Boston* 15, *Mass.*

CIRCLE 219 ON READER-SERVICE CARD

X-RAY GAGE

New small-size Models XactRay of a short-pulse x-Ray Thickness Gage are for measurements ranging from foil thicknesses of 0.00025″ to plate thicknesses of 1.5″. Using a sharply-pulsed, pencil x-ray beam, it measures thickness (from end to end and

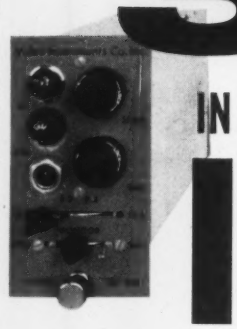
side to side) of plastics, rubber, paper, fabrics, steel (hot and cold rolled), copper, brass, aluminum, and many other materials and metals at speeds up to 6000 ft/min and to tolerances of ±0.000010″. Unit consists of an x-ray generator, x-ray incident unit, and indicator console. Features include a low noise level, compensating device for varying material densities, and absolute thickness calibration, constant for the life of the gage.—*Daystrom-Weston Sales Div., Daystrom, Inc.*, 614 *Frelinghuysen Ave., Newark* 12, *N. J.*

CIRCLE 220 ON READER-SERVICE CARD

DIGITAL DATA LINK

New Model DL-100 Digital Data Link, for the transmission of digital

3 IN 1



power supply range and balance calibration in one

STRAIN GAGE MODULE

Fully transistorized, the power supply can be set for either voltage or current regulation by means of an internal switch. The span adjustment provides a choice of excitation voltages, continuously variable from 0 to 15 volts. The wide range balance control is suitable for use with virtually all transducers. There is a choice of four precision calibration resistors. Excitation voltage and gage signal voltage monitoring is provided.

Output	floating, 0 to 15v at 200 ma
Line Regulation	better than 0.1%
Load Regulation	better than 0.1%
Ripple	less than 1 mv
Noise and Hum to Ground	less than 10 microvolts peak to peak when measured with a 350 ohm strain gage bridge
Leakage Resistance	at least 10,000 megohms
Price	$145 plus calibration resistors, fob Santa Monica, Calif.

VIDEO INSTRUMENTS CO., INC.

3002 Pennsylvania Ave., Santa Monica, Calif.

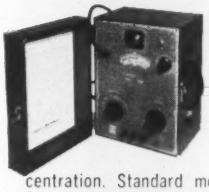
Vi

at ISA, visit Vi... booth 163

CIRCLE 103 ON READER-SERVICE CARD

ELECTROLYTIC CONDUCTIVITY EQUIPMENT

CONDUCTIVITY BRIDGES



Industrial Instruments offers a **complete** line of electrolytic conductivity bridges for the measurement and control of solution concentration. Standard models are available for use in conductive solutions ranging from distilled water to concentrated acids or alkalis, and in all temperature ranges.

CONDUCTIVITY CONTROLLERS

For steam generation, water purification, chemical processing general lab work, and wherever continuous indication and/or control of solution conductivity is required Industrial Instruments has a wide line of practical instruments designed specifically for the job. Also available are conductivity recorders in circular and strip-chart, single and multi-point types as well as battery-operated units.

CONDUCTIVITY CELLS

A single source for all your cell needs. Body materials in the widest range of materials to meet every requirement for temperature, pressure and corrosion resistance. Complete selection of cells designed to meet your application requirements... no universal compromises. Nickel platinum, graphite, gold or tin electrode materials as well as a comprehensive selection of cell constants and ranges for every measurement application.

Write for your personal copy of our new Catalog #23.

Industrial Instruments Inc.

89 Commerce Road, Cedar Grove, Essex County, N. J.

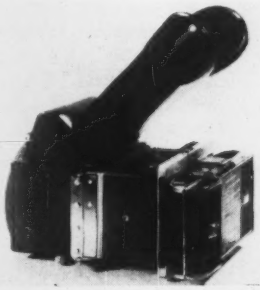
CIRCLE 104 ON READER-SERVICE CARD

data over standard communications channels at rates up to 33,000 bits/-sec, is an integrated transmit-receive unit, capable of sending or receiving over 20,000 pages of printed matter in one eight-hour shift. The output magnetic tape is usable directly in computer format for the entry and solution of problems or can be printed out in report form for local distribution.—*Epsco, Incorporated, 275 Massachusetts Ave., Cambridge, Mass.*

CIRCLE 221 ON READER-SERVICE CARD

OSCILLOSCOPE CAMERA

New Oscilloscope Recording System, the Direct-View Oscillotron, permits to view cathode-ray tubes in a

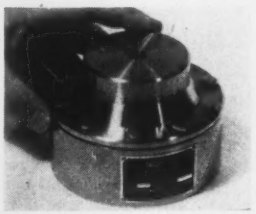


direct line of sight while recording. Available with a Polaroid Land back, electrically-pulsed 35-mm or 70-mm magazine for automatic remote operation, or continuous-motion magazines.—*Beattie-Coleman, Inc., 1000 N. Olive St., Anaheim, Calif.*

CIRCLE 222 ON READER-SERVICE CARD

BACK-PRESSURE VALVES

Two new Back-Pressure Valves, Type 26 Models A and B, with all wetted metallic parts made of stain-

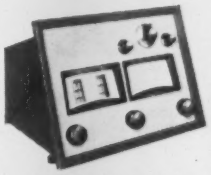


less steel, maintain a constant hydraulic back-pressure within ±0.1 psi through a broad flow range of 10:1. Model A, an angle-style diaphragm pressure relief valve, can be controlled either hydraulically or pneumatically by a remotely-located pilot pressure regulating valve over a pressure range from 2 to 100 psig. Model B is completely self-operating with an air-loading chamber above the diaphragm.—*Cax Instruments Div. of George L. Nankervis Co., 15300 Fullerton Ave., Detroit 27, Mich.*

CIRCLE 223 ON READER-SERVICE CARD

THERMAL CONDUCTIVITY EQUIPMENT

Therma Bridge GAS ANALYZER

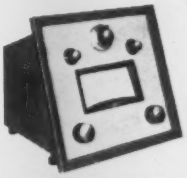


For monitoring purity values in gas streams and for wide applications in gas impurity analysis. Completely self-contained unit with sensing cells, precision machined gas trains, newly designed dessicant drier columns, control circuit and power supply. Functionally designed with all controls located in convenient positions.

Therma Bridge SENSING CELLS

Advanced design provides greater output response. Available in two metal mass weights. Heavyweight, open-core, hexagonal cell and light-walled, individual cavity type. All units provide low background noise, super-smooth electrical balance, improved sensitivity and heat transfer.

Therma Bridge POWER SUPPLY



Power supply and control circuit unit readily adaptable as a power source for any thermal conductivity sensing cell or for any other requirement demanding a precisely regulated output voltage and currents between 30 and 500 milliamperes. Unit utilizes selenium rectifier full wave bridge circuit with high efficiency transistorized error amplifiers.

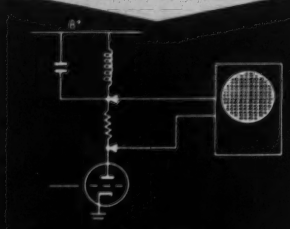
Write for descriptive literature...

Industrial Instruments Engineering Corp.

89 Commerce Road, Cedar Grove, Essex County, N. J.

CIRCLE 105 ON READER-SERVICE CARD

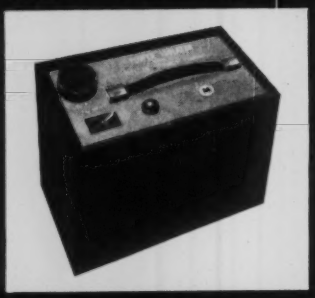
Ever try a measurement like this?



2 things happen . . .

(1) power line current flows in scope and circuit—only 60 cycles show: (2) triode is loaded by shunt capacitance to ground . . . and gain changes.

Solution:
Use a Moeller Power Isolator to power scope or circuit.



Now Moeller Power Isolator supplies ideal isolation for line operated devices. Common grounding is not necessary. Use with oscilloscopes, voltmeters, amplifiers, signal generators, power supplies, recorders, or any line operated test equipment.

The Model 30 Power Isolator can supply up to 300 VA of isolated power at 115 VAC 60 cycle. Output impedance to ground <2 ppf and $>50{,}000$ megohms in parallel.

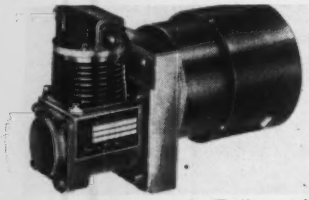
Write for descriptive literature.

Quality industrial instrumentation since 1867
MOELLER INSTRUMENT CO.
ELECTRONICS DIVISION
13th St. & 89 Ave., Richmond Hill 18, N. Y.

See this unit in operation at Booth L-7 Wescon
CIRCLE 106 ON READER-SERVICE CARD

SINGLE-PISTON AIR PUMP

New air pump, Dynetics Model 04-301, a precision, multipurpose single-piston air pump designed for the production of oil-free compressed air,

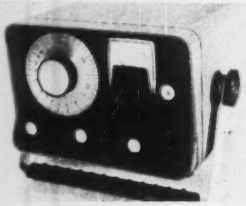


uses Graphitar, and Teflon piston rings. Capacity of pump at 50 psig is 127 cu in/min. Available with a ⅛-hp, 400-cycle motor, either single-phase at 115 v or three-phase at 200 v.—*Applied Dynamics Corp., 32 North Main St., Natick, Mass.*

CIRCLE 224 ON READER-SERVICE CARD

SIGNAL GENERATOR

New portable Model N-1 Series Signal Generator which is transistorized

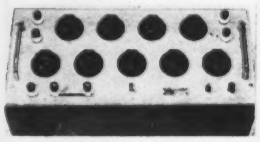


and battery-powered and has a continuously-variable frequency range from 2 cps to 200 kc, provides 1-v rms output with less than 1% distortion. Calibration accuracy is better than 2% for frequency and 5% for level on all ranges.—*Southwestern Industrial Electronics Co., a Div. of Dresser Industries, Inc., 10201 Westheimer Rd., P. O. Box 13058, Houston 19, Texas.*

CIRCLE 225 ON READER-SERVICE CARD

WHEATSTONE & LIMIT BRIDGE

New precision Wheatstone Bridge and Limit Bridge Model E-1028, has an over-all range from 0.1 ohm to 111.11 meg-ohms, obtained by (1) two



independent ratio dials which will give ratios from 1:10,000 to 10,000:1; and (2) a five-decade rheostat giving steps of 10 x (0.1 + 1 + 10 +100 + 1000). The same ratio dials and rheostat decades are used with the limit bridge, with two additional dials being used to set percentage limits.—*Gray Instrument Co., Andalusia, Penna.*

CIRCLE 189 ON READER-SERVICE CARD

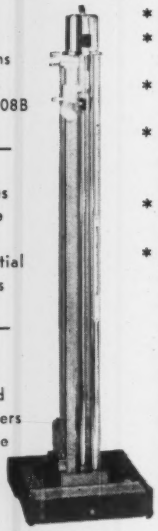
PRECISION—MERCURIAL BAROMETERS—MANOMETERS

AVAILABLE WITH ANY OR ALL OF THESE FEATURES:

Conforms to Spec. Mil-B-4308B

Measures Absolute or Differential Pressures

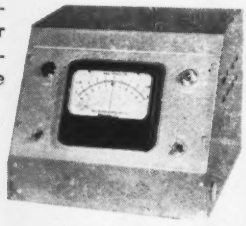
Primary Standard Barometers Available



31" Type A-1 Barometer

* Range 0-31", 0-62" and 0-105" inches of mercury.
* Complete Temperature and gravity compensation.
* Direct true pressure readings with accuracy guaranteed to .02% of full scale.
* Manual Sighting or Photo Electric Scanner indicating pressure changes of less than 0.01 mm mercury.
* Stop-bar mechanism for production testing at predetermined points.
* Choice of scale graduations: inches, millimeters, millibars, altitude or special.

Used by the U. S. Air Force, and instrument manufacturers for the calibration of Altimeters, Air Speed Indicators, Automatic Pilots, Altitude Switches, Thrust Meters, Machmeters, Air Data Computers, etc.



Amplifier for Photo Scanner

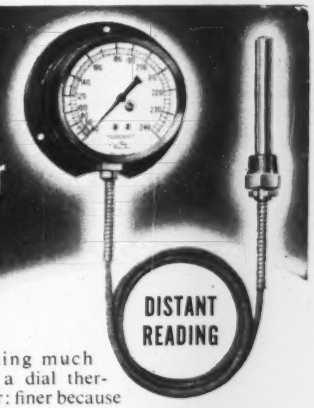
Phone Hickory 9-5454

For more information or special application write to:

THE **HASS INSTRUMENT** CORPORATION
6173 BRANCH AVENUE **WASHINGTON 23, D. C.**

CIRCLE 107 ON READER-SERVICE CARD

The dial thermometer at its best



Something much finer in a dial thermometer: finer because it is the bourdon tube type of thermometer at its best...embodies the greater precision and lasting accuracy of the Marsh Pressure Gauge.

Both vapor tension and gas-filled types are available in either distant reading or rigid stem types. In the broad Marsh line you have a complete selection of temperature ranges, case sizes, styles, and finishes.

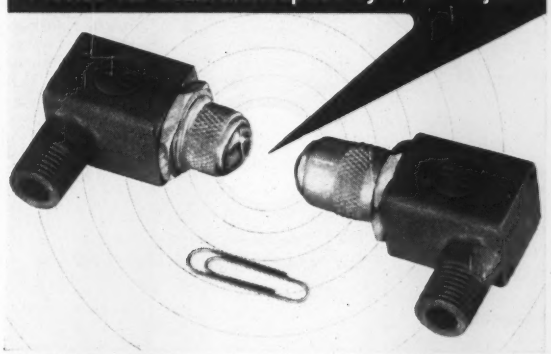
Ask for the Thermometer Catalog

MARSH

MARSH INSTRUMENT COMPANY, Dept. 42, Skokie, Ill.
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co., (Canada) Ltd.
8307 103rd St., Edmonton, Alberta, Canada
Houston Branch Plant, 1121 Rothwell St.
Sect. 15, Houston, Texas

CIRCLE 108 ON READER-SERVICE CARD

MINIATURE PHOTOELECTRIC SCANNERS
Provide for beam-interruption by 1/32" object



This exceptionally small, precise sensing device assures ultra-precise limit switching, machine and edge control; actuates controls in production or inspection lines.

FEATURES:

- Operated by direct beam, or by reflected beam when heads are mounted side by side in special installations.
- Dark or light energizing; response to beam-interruption of less than 1 millisecond with adjustable relay hold-in time; delayed relay response adjustable to 1 second; direct relay operation provided by 3 types of relays.
- Cadmium-selenide photocell gives short-span, moderate-speed operation; adding an electronic relay increases distance to 6 feet. Lead-sulphide cell with electronic relay gives high-speed operation, sharp resolution.
- Heads have provision for panel mounting, rear-of-housing attachment, or conduit mounting with ¼" pipe thread.
- Life of light source in excess of 5000 hours.

Write for data sheet.

FARMER ELECTRIC
Products Company, Incorporated
2300 WASHINGTON ST. NEWTON LOWER FALLS, MASS

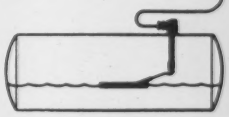
CIRCLE 109 ON READER-SERVICE CARD

100% AUTOMATIC TANK GAUGING

Dependable remote reading tank contents gauges using a closed hydraulic transmission system. No power required.

Several sizes available. Approved by Underwriters Laboratories and Factory Mutual. UL approved switches.

Write for complete details, to Dept. **E**



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LONG ISLAND CITY 1, NEW YORK

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By MOSER JEWEL COMPANY, pioneer industrial jewel manufacturer for over 50 years.

- HIGHLY POLISHED STEEL PIVOTS AND STAFFS
- HARD ALLOY WELDED TIPS
- NON-MAGNETIC STAFFS
- DIAMOND POINTS

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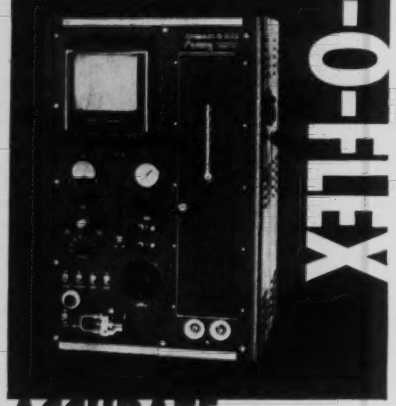
CIRCLE 111 ON READER-SERVICE CARD

LOENCO

CHROMAT-O-FLEX



ACCURATE HIGH-SPEED CHROMATOGRAPH ANALYSIS

over a wide temperature range

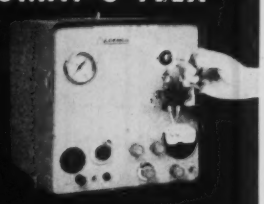
model 1A features:

- Dual column switching with automatic backflush
- Multi-stage connection adaptors
- High performance detector for either filament or thermistor elements
- Ample oven space
- Precise electronic temperature control, proportional type
- Choice of sample introduction techniques
- Choice of high sensitivity recorders, integrators supplied if desired

NEW COMPACT

CHROMAT-O-FLEX

from $640



model 15 features:

- Measures 13¼" x 13¼" x 12". Wt. 35 lbs.
- Temperature range — from Ambient to 250°C. At small extra cost to 350°C.
- High sensitivity, shielded filament element detector
- Hot sample outlet fitting for sample collection
- Ample oven space for long columns
- Available with gas sample valve, column reverse valve, electronic proportional temperature controller

NOW SPEED UP ANALYSES WITH A LOENCO CHROMAT-O-FLEX

For Full Details, Contact

LOENCO

LOE ENGINEERING CO.

237 North Fair Oaks Ave. • Pasadena, California

CIRCLE 112 ON READER-SERVICE CARD

DIFFERENTIAL-PRESSURE/ VACUUM CONTROLLER

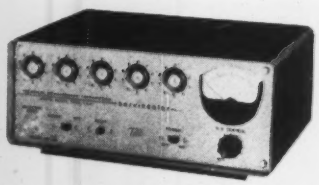
New Type J94K Differential Pressure Controller is available in five models, between the limits of 30" Hg and 40 psig with switch differentials

from 0.5 ± 1/10" Hg and up. Controller is uncalibrated and pressure settings are made up by removing the cover and adjusting the hex-head adjustment screw. Housing is explosion proof. SP switch actions include: n-o, n-c, or DT with no neutral position. Rating is 15 or 20 a, 115/230 vac.—*United Electric Controls Co., 85 School St., Watertown 72, Mass.*

CIRCLE 226 ON READER-SERVICE CARD

TRANSISTORIZED SCALER

New Model SG-10A Serviscaler, a transistorized Scaler, specifically designed for training and classroom use has only one tube—the high-voltage regulator. Maximum capacity is 99,999 counts which are registered on five decade glow-transfer tubes. The resolving time is better than 200 μs; high-voltage supply stability is 1.0% and average input sensitivity is 75 mv.—*Technical Measurement Corp., 441 Washington Ave., North Haven, Conn.*



CIRCLE 227 ON READER-SERVICE CARD

TAPE WINDER/UNWINDER

New Portable Tape Winder has a motor-driven 12" reel holding more than 1300 feet of chadless punched tape—New Tape Unwinder is so designed that punched tape removed from Winder can be placed on the reel of the Unwinder and fed into a transmitter from the center of the roll. It is light-weight and portable and can be set on any flat surface of proper dimensions.—Two 2-page pamphlets give details.—*Western Apparatus Co., 2001 Greenleaf St., Evanston, Ill.*

CIRCLE 228 ON READER-SERVICE CARD

For your library . . .

Printed Circuitry

by Allan Lytel. A valuable working tool; includes alternative and recommended practice for each step in design and production of printed circuits; a buyer's guide to special components; and "how to" service data. Paperbound, illustrated, 192 pages, 1957. $2.00

Maintenance and Servicing of Electrical Instruments

by James Spencer. Useful to all instrument users, service men, switchboard attendants testing engineers, and others, this book covers construction, testing, applications, principles of operation and maintenance of all kinds of electrical indicating instruments. Clothbound, 274 illustrations, 280 pages, 1951 (third edition). $2.00

Process Control Analysis

by M. H. LaJoy and E. A. Baillif. An essential first step in analysis of closed-loop controlled processes via frequency response of the system. Clothbound, 72 pages, 1956. $2.00

Strain Gage Instrumentation

edited by Aronson and Nelson. " . . . a practical text . . . covers fundamentals, basic bridge circuits, typical applications, and surveys typical commercial instruments which use or are used with strain gages." Paper, 110 pages, illustrated, indexed by company, author, and subject, 1958. $2.00

Digital Techniques for Computation and Control

by Klein, Morgan and Aronson . . . all basic digital techniques within one text . . . code arithmetic, logical networks, multiplexing, conversion, data reduction, digital process control, two-terminal relay circuits, counting techniques, digital computers, programming, digital differential analyzers, and combined analog-digital equipments. Cloth, 394 pages, illustrated, 1958. $6.00

Nuclear Reactors for Industry and Universities

edited by E. H. Wakefield. The several distinguished authors and editor Wakefield cover types, availability (1954), operation, protection, control, experiments, legal aspects, and present a detailed cost study. Cloth, 92 pages, illustrated, 1954. $2.00

Heat Inertia Problems of Automatic Control of Temperature

by Victor Broida . . . "fictitious mass" concept of heating process unit under automatic control. Paper, 61 pages, 1950. $1.00

Instruments Publishing Co.

845 Ridge Avenue

Pittsburgh 12, Pennsylvania

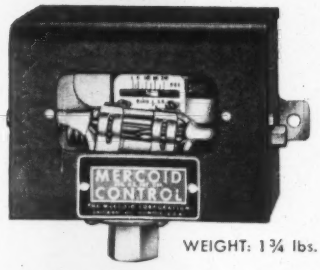
CIRCLE 113 ON READER-SERVICE CARD

NEW

Small, Lightweight

MERCOID PRESSURE CONTROL

AP-153

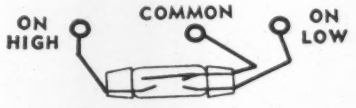


WEIGHT: 1¾ lbs.

FOR MEDIUMS NOT INJURIOUS TO STEEL OR SILVER SOLDER

CIRCUIT

SP-DT HERMETICALLY SEALED MERCURY SWITCH (4A. 115V., 2A. 230V.)



Provides any of following operations:

1. *Single Pole—Cut-in high (close on rise)*
2. *Single Pole—Cut-in low (open on rise)*
3. *Single Pole—Double Throw*

OPERATING RANGE

ADJUSTABLE OPERATING RANGE	SWITCH DIFFERENTIAL PSIG. With Pointer Set At LOW	HIGH
1 to 20 psig.	0.3	0.5

CONSTRUCTION

ADJUSTMENT: External
PRESSURE ELEMENT: Fairprene diaphragm
PRESSURE CONNECTION: ¼" I.P.S.
MOUNTING: Has two mounting ears (one on each side of control) or control may be pipe mounted by means of the ¼" I.P.S. bottom connection.
INTERNAL WIRING CONNECTIONS: 3 post terminal block.
CASE: NEMA 1—Heavy gauge steel, cadmium plated. Steel cover (with glass front) finished in charcoal-gray.

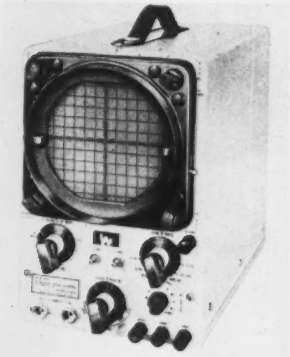
WRITE FOR BULLETIN 02

THE MERCOID CORPORATION
4201 Belmont Ave., Chicago 41, Ill.

CIRCLE 114 ON READER-SERVICE CARD

5" OSCILLOSCOPE

New S-16-A Craftscope, a portable 5" Oscilloscope, features d-c to 7-Mc response, direct-reading vertical cali-



bration, wide-range repetitive sweep with additional fixed sweeps for color- and ITV-work, trace inversion, edge-lighted graph screen, etc.—*Waterman Products Co., Inc., 2445-63 Emerald St., Phila. 25, Pa.*

CIRCLE 229 ON READER-SERVICE CARD

CARRIER SYSTEM

New Series 3000 amplitude-modulated Carrier System provides ultra-stable 3-kc transducer excitation at

20 v rms, solid-state demodulator circuitry. System with modular design, offers series injection electrical calibration manually, automatically or sequentially.—4-page Bulletin 109 gives details.—*Wiancko Engineering Co., 255 N. Halstead, Pasadena, Calif.*

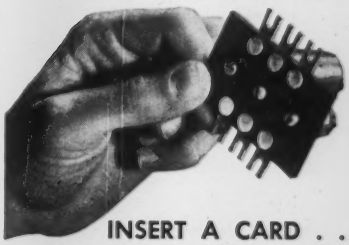
CIRCLE 230 ON READER-SERVICE CARD

HAND PUMP COUNTER

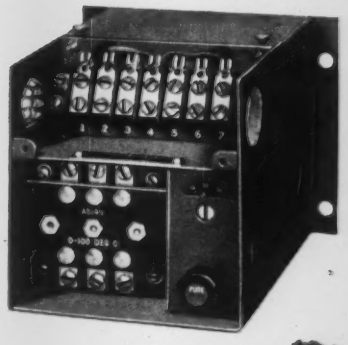
New low cost Pump Counter to indicate flow of fuels, chemicals and other liquids, can be mounted on any hand-operated model. Key to the counter is a ball-clutch-drive arrangement that insures totalizing of partial strokes in either direction. A reset counting unit and a non-reset totalizing unit indicate gallons, quarts, or other quantities.—*Veeder-Root Inc., Hartford 2, Conn.*

CIRCLE 231 ON READER-SERVICE CARD

Great things are happening in AutroniC® Control



INSERT A CARD . . . CHANGE THE RANGE



LOW-COST, HIGH-PERFORMANCE ELECTRONIC RESISTANCE THERMOMETER

Pick a temperature range between —50° and 700°F., or —50° and 350°C.; place the corresponding range card in the Swartwout thermometer adapter, and the temperature range is set up, ready to go.

Simple? You bet. Simplified design is the reason for the low price of the Swartwout Resistance Thermometer. It is also the reason for the unit's exceptional dependability.

Highly sensitive, the fully-electronic Swartwout Resistance Thermometer temperature system is adaptable to full-scale temperature spans as small as 3°F. It can indicate, record, or control. With slight modification, or auxiliary equipment, it will add, subtract or average temperature . . . even control the ratio between two temperatures, or between temperature and another variable.

All this is done with electronic speed. Data is transmitted instantaneously . . . no time-lag no matter where temperature elements are located.

The operational ease, functional flexibility and simplicity of the Resistance Thermometer are characteristic of the entire line of Swartwout AutroniC Instrumentation.

For details on the Resistance Thermometer, request Bulletin A-706-B. The Swartwout Co., 18511 Euclid Avenue, Cleveland 12, Ohio.

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S.A. 1999

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High-Speed OPTICS

For Image Amplifiers—Speeds Equal to F/0.5

- Designed for use with RCA—Phillips — Bendix — Friez — Westinghouse and cascading image amplifiers. One to one systems of extreme speed — short focal lengths.
- New Optical Systems available for prompt delivery from stock. State full data for quotation. Ideal for X-Ray — Radiation research and astronomic telescopes.
- Other optics, photo and recording equipment available from world's largest "LENS BANK" — Write for Encyclopedia Catalog

BURKE & JAMES, INC.
321 S. Wabash Chicago 4, Illinois

CIRCLE 116 ON READER-SERVICE CARD

OPTIMAL-MODE CONTROLLER

New optimal-mode controller, Maximizer Model 760-W, controls only for zero slope (a choice of a maximum or a minimum) unlike the original models, which control at any slope on

the process curve. However, they are true slope controllers, not peak-seeking devices. To find a maximum they need approach only from one side and once at the peak, the control action is stable. Input is a d-c mv signal with adjustable sensitivity. Output is a modulated time signal with up to 100 w of power available.—16-page booklet gives details.—*Quarie Controllers, 381 North Main St., Sharon, Mass.*

CIRCLE 232 ON READER-SERVICE CARD

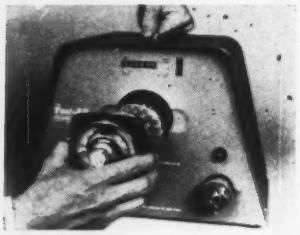
HARDNESS TESTER

New Sklero Hardness Tester enables the user to make on-the-spot hardness readings without moving the test piece to large stationary equipment. Reading accuracy is within ±1-point Rockwell C. Test readings can be converted to Rockwell Shore, or Brinell by the special conversion table provided.—*Precise Products Corp., 3715 Blue River Rd., Racine, Wis.*

CIRCLE 233 ON READER-SERVICE CARD

UNIVERSAL TESTER

New Test-All, a packaged Universal Tester, performs a wide variety of repetitive test functions, such as life, duty cycle, temperature rise, or load tests on motors, relays, transistors, vacuum tubes, solenoids, trans-



formers, etc. Nine standard dial ranges are available. An over-ride control permits either automatic start or shut-down of test from a remote control device such as a counter, limit switch, or temperature signal.—*Automatic Timing & Controls, Inc., King of Prussia, Penna.*

CIRCLE 234 ON READER-SERVICE CARD

THIS 346-PAGE HANDBOOK CONTAINS EVERYTHING YOU SHOULD KNOW ABOUT PERMANENT MAGNETS

The most comprehensive manual of its kind! It contains all the data you need to design permanent magnets into generators, meters, compasses, hi-fi and TV systems, etc. It analyzes 60 different magnet materials — discusses measurements, ferromagnetism, electromagnetic theory, etc. For your copy of this *Permanent Magnet Handbook*, send check or money order for $10* to *Crucible Steel Company of America, P. O. Box 2518, The Oliver Bldg., Mellon Square, Pittsburgh, Pa.*

*If you are located in Pennsylvania, add 35c for state sales tax.

CRUCIBLE STEEL COMPANY OF AMERICA

CIRCLE 117 ON READER-SERVICE CARD

STRAIN GAGE and TRANSDUCER INPUT CONDITIONING EQUIPMENT

for data accumulation and processing systems

Standard and custom models with modular or unitized construction in any number of channels. Rack mounted for ground stations, compact packages for flight.

Typical Modular Plug-In System. 88 channels. 19" x 11" x 6". Designed to withstand shock, vibration and water spray.

FEATURES

- Separate or common bridge voltage inputs.
- Common mode rejection for feeding differential amplifiers.
- Manual or automatic calibration, series or shunt.
- Designed to feed multi-channel recorders or standard scanning devices.
- Complete versatility achieved with individual channel controls.

Detailed information available on request.

B&F instruments, Inc.
3644 N. LAWRENCE ST. PHILA. 40, PA.

OTHER PRODUCTS: TORQUE METER SYSTEMS, ACCELEROMETERS

CIRCLE 118 ON READER-SERVICE CARD

product index

The following is a handy reference to products (and their reader-service number) advertised or reported in this issue. For more information on any product mentioned, circle the corresponding number on the reader-service card at the right.

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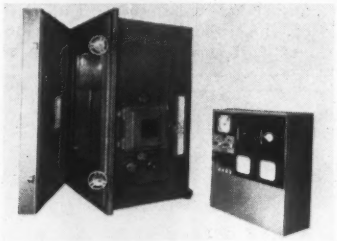
New Standco line of Running Time Meters (Elapsed Time Meters) registers in hours and tenths of hours, hours only, or minutes only, and is available for 115v, 220v, and 440v, 60

cps or 50 cps, and in 3½" and 2½" flush-mounting, panel type of meter, both in bakelite and metalcases, unsealed, and hermetically sealed in accordance with military specifications. —*Herman H. Sticht Co., 27 Park Place, New York 7, N. Y.*

CIRCLE 235 ON READER-SERVICE CARD

TEMPERATURE TEST CHAMBER

New Altitude-Temperature Test Chamber features true vertical air flow and provides temperatures from

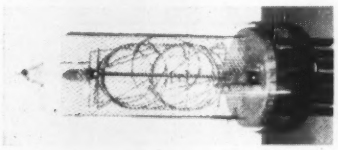


−100° F to +350° F and altitude simulation from ambient to 100,000 ft. and higher.—*American Research Corp., Farmington, Conn.*

CIRCLE 236 ON READER-SERVICE CARD

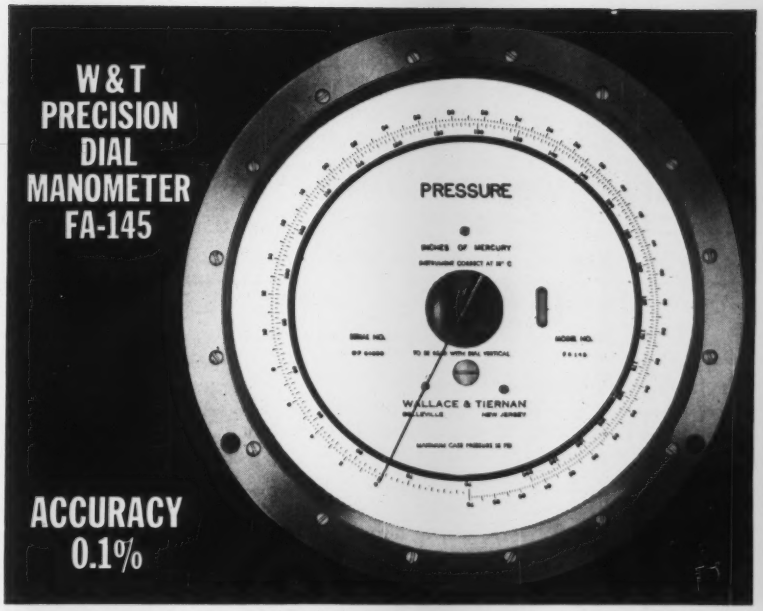
COLD-CATHODE LOAD TUBE

New Digitron, a Cold-Cathode Load Tube, can be added to existing counter circuits to display the state of count



of either hard-tube counting circuits, or cold-cathode load tube decades. Ideal for indicating the position of selector or stepping switches on a remote panel or monitor board. Numerals are 1½" high.—*Baird-Atomic, Inc., 33 University Rd., Cambridge 38, Mass.*

CIRCLE 237 ON READER-SERVICE CARD



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MANOMETERS—CIRCLE 119 ON READER SERVICE CARD
CHLORINATION—CIRCLE 120 ON READER SERVICE CARD

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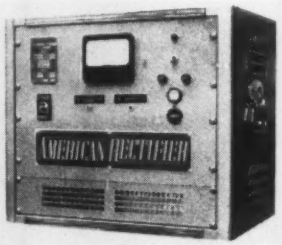
CIRCLE 121 ON READER-SERVICE CARD

AC VOLTAGE REGULATORS

New Selenivac line of heavy-duty electromechanical a-c Voltage Regulators is for 25, 50, 60- or 400-cycle operation and provides ±1% control with no waveform distortion. Input



voltages may be one-phase, two-phase (3 or 4 wire) and three-phase. Present line includes ratings from 1 kva to 300 kva and any input or output voltage up to 600 v.—*American Rectifier Corp., 95 Lafayette St., New York 13, N. Y.*

CIRCLE 238 ON READER-SERVICE CARD

TRIODE TUBE

New Triode Tube WL-7215 for communications and radio frequency heating service is rated at 18-kw input and 9-kw dissipation. Full rating of the tube applies to 60 Mc; 80% of full power is applicable at

how to ENGRAVE PANELS & SIGNS to 30" wide by any length

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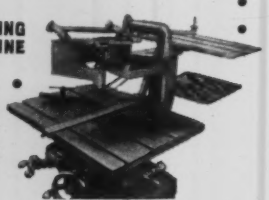

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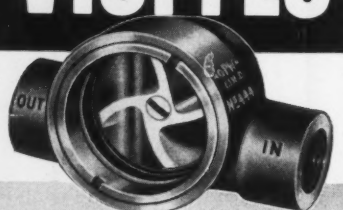
CIRCLE 123 ON READER-SERVICE CARD

One look to know!
OPW VISI-FLO



OPW VISI-FLO sight glass indicators are a trustworthy visible means of alerting you as to rate of flow, viscosity, color of liquids, clarity, and purity of product.

OPW VISI-FLO protects you against line stoppage, helps maintain uniformity, a high standard of product quality and an even continuity of production.

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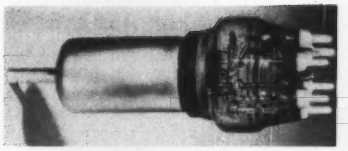
CIRCLE 124 ON READER-SERVICE CARD

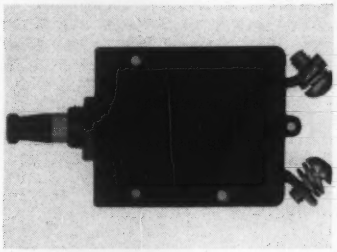


100 Mc. It features an integral water jacket and a long life thoriated tungsten filament.—*Westinghouse Electric Corp., Electronic Tube Div., P. O. Box 284, Elmira, N. Y.*

CIRCLE 239 ON READER-SERVICE CARD

CIRCUIT BREAKER

New commercial model Circuit Breaker, 2300 Series, weighs only



2-½ oz, has push-pull button action, protects circuits up to 5000 amps, 120 v., 60 cps, is highly shock-resistant, and is precision calibrated.—8-page bulletin contains details.—*Wood Electric Co., 244 Broad St., Lynn, Mass.*

CIRCLE 240 ON READER-SERVICE CARD

Miniature FAST-RESPONDING Surface THERMOCOUPLE

New Design Features Offer for the First Time a Thermocouple with:

- A Response Time of Less than 10 Microseconds
- A Maximum Continuous Service Temperature of Over 2000°F.
- An Operating Pressure Range to 50,000 psi
- A Sensing Tip with unlimited Life

Revolutionary design uses thin ribbon thermocouple wires and mica insulation of .0002 inches thickness. Will operate under extremely high velocity and high pressure conditions.

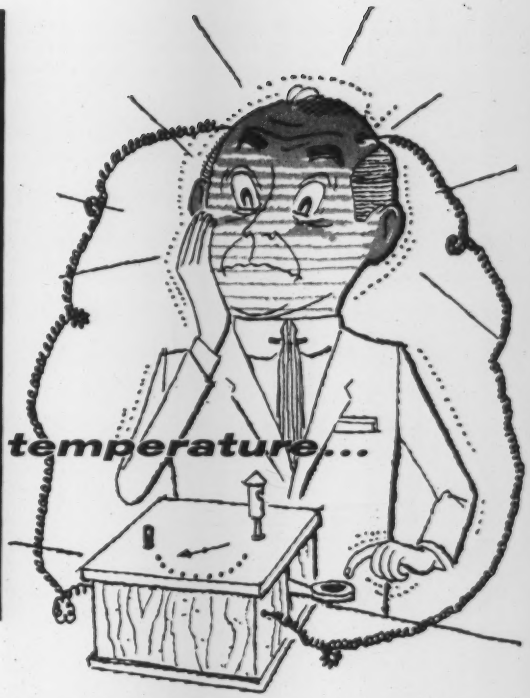
Available in iron-constantan, chromel-alumel, or platinum-platinum/10% rhodium standard thermocouple elements.

For additional details and models write for Bulletin No. TB 159.

NANMAC CORPORATION
P. O. Box 8, Indian Head, Md.

CIRCLE 125 ON READER-SERVICE CARD

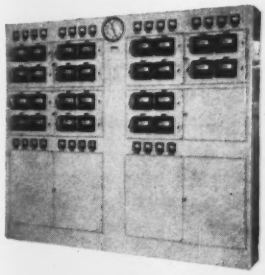
How to control your temperature...



Your personal temperature may soar when you see the advantages that others gain by improving control of temperature in operations like yours. But you can confidently control both types of temperature by using our consulting service and, if necessary, some of our instruments.

For we are specialists in temperature control. Our worldwide field force is constantly working with situations like yours, seeking waste and hidden potentials where "control is no problem." Working with your own people, chances are they'll find ways to boost your production...assure quality... reduce costs.

We provide such service without charge, to determine whether you really need our indicators or controllers or recorders, thermocouples and accessories. Chances are that you do; for our instruments soon save their cost in avoiding work-stoppage and reducing maintenance.



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Any combination of our instruments, complete with accessories and wiring, is factory-installed in a compact steel cabinet to suit your situation. At the other extreme, we offer a complete selection of our own thermocouples and accessories priced and ready to ship at your convenience. Phone your West consultant (see Yellow pages) or write Chicago office for Bulletin CS or for COM digest-catalog of line.

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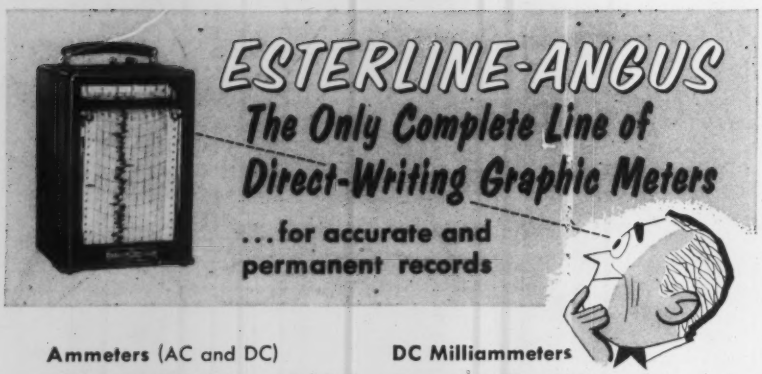

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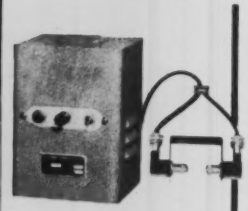
CIRCLE 127 ON READER-SERVICE CARD

POST DECITRON ELECTRONIC PRODUCTS

Photoelectronic Controls



Model K-1 with Miniature Photohead
This is a general purpose photoelectric control whereby the interruption of a light beam in the photohead closes a relay which can be used to activate an external circuit.

Model K-3
The K-3 control differs from the K-1 in that the output relay will not energize for each interruption of the light beam, but only if interruptions cease. Can be used to detect "flow" stoppage.

Model H-21-C
The compact, long life, *miniature* photohead . . . ideal for mounting in limited space. May be furnished with alignment brackets to insure proper relation of light source and receiver.

Decitron

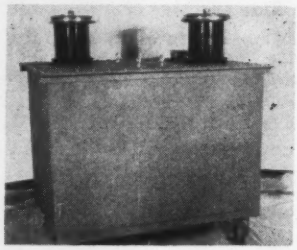
ELECTRONIC PRODUCTS DIVISION

Post Machinery Co. | 159 Elliott St., Beverly, Mass.

CIRCLE 128 ON READER-SERVICE CARD

HIGH-VOLTAGE TEST SETS

New model Test Set with 200 kv rms output for testing high-voltage tubes, cables and bushings, all dielectric materials, and high voltage ap-

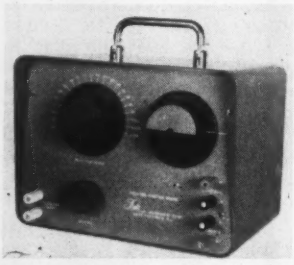


paratus in general, in accordance with ASTM testing methods, is available in many sizes from 2 kva to 100 kva.—*Peschel Electronics, Inc., R.F.D.* #1, *Towners, Patterson, N. Y.*

CIRCLE 241 ON READER-SERVICE CARD

RESOLVER ERROR BRIDGE

Computing resolvers are tested for deviation from ideal sine or cosine, which is expressed on 4½" zero-center meter as percentage error.

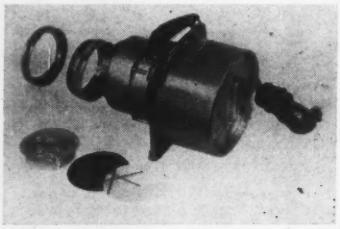


High balance sensitivity is achieved by matching carrier phase of standard voltage to resolver output. Detector blocks all harmonic and quadrature voltages.—*Theta Instrument Corp.,* 48 *Pine St., East Paterson, N. J.*

CIRCLE 242 ON READER-SERVICE CARD

AIR SAMPLER

New high volume air sampler for elimination of small concentrations of particulate contamination has ap-



plications in tests of rocket and missile exhausts, smoke and smog analysis, mines and factories, armed force research units, municipal air pollution, etc. Described with other models in new bulletin 1-H4 on request.—*The Staplex Co., Air Sampler Div., 777 Fifth Ave., Brooklyn* 32, *N. Y.*

CIRCLE 243 ON READER-SERVICE CARD

SUBMIN ALTITUDE SWITCH

New 3 oz altitude switch can be preset to close or open contact at any altitude from 2000 to 70,000 ft. Ac-

curacy is within 2% of setting through −65° to 250°F range.—*Aero Mechanism, Inc.*, 8938 *Lindblade St., Culver City, Calif.*

CIRCLE 244 ON READER-SERVICE CARD

POCKET COMPARATOR

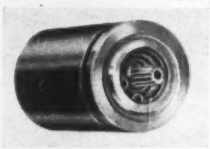
Six-power magnification and etched reticle make new pocket-sized comparator an accurate tool for checking small dimensions in miniaturized

production and inspections. Sand measuring, 20mm scale, and magnetic character reticles are also available. —*Edmund Scientific Co., Barrington, N. J.*

CIRCLE 245 ON READER-SERVICE CARD

TRANSISTOR DRIVEN SIZE 8 SERVO

New size 8 servo motor, BT 705-1, designed for operation from transistorized circuits develops 0.33 oz-in stall torque for missile applications.

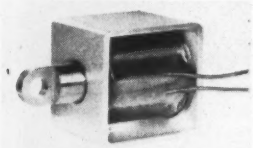


Two-phase motor has 26 v on fixed phase and center-tapped control phase of 20-0-20 v.—*Induction Motors Corp., 570 Main St., Westbury, N. Y.*

CIRCLE 246 ON READER-SERVICE CARD

LONG-LIFE SOLENOIDS

New line of "long-life" Solenoids, designed for 100 million or more operations, has a machine-tool-type



bearing as a plunger guide and features precision fit of guide and plunger.—*Automatic Switch Co., Florham Park, N. J.*

CIRCLE 247 ON READER-SERVICE CARD

lightest weight/easiest installation/silent no hum operation

NEW HOKE

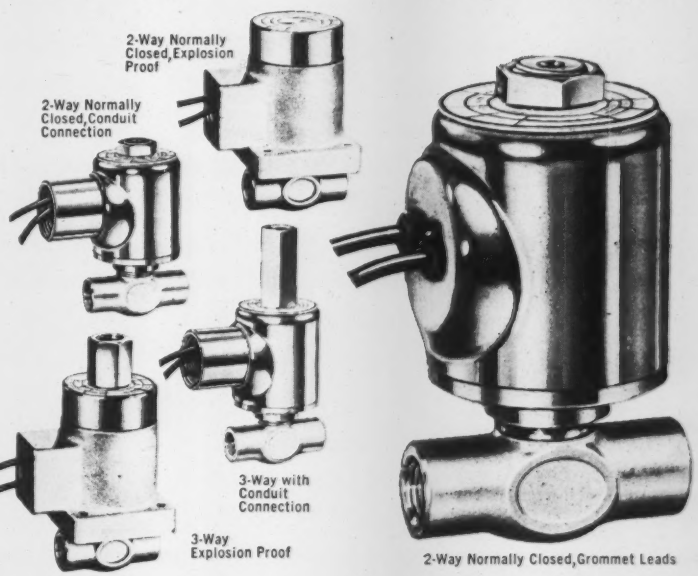
lowest temperature rise and power consumption

SOLENOID

stainless steel plunger design/silver ac shading coil

VALVES

smallest size/packless construction/operates any position


2-Way Normally Closed, Explosion Proof
2-Way Normally Closed, Conduit Connection
3-Way with Conduit Connection
3-Way Explosion Proof
2-Way Normally Closed, Grommet Leads

The lightest, smallest direct-acting solenoid valve available, featuring many innovations in design plus the usual, high-quality standards of all Hoke products. Two-way and three-way types (Series 90 and Series 95), with brass or stainless steel bodies are in production, in standard female connection sizes: 1/8" and 1/4" as well as 1/4" OD tube, 37° flare. Orifice sizes from 1/32" to 1/8". Mount in any position; a 360° rotatable coil housing permits connections from any angle. Choice of materials for valve discs and body gaskets. Variations in basic design to fit your needs. Competitively priced!

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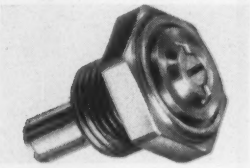
CIRCLE 129 ON READER-SERVICE CARD

OVERHEAT INDICATOR

New overheat temperature indicator used to detect an overheat condition in an engine during flight provides a visual check for ground

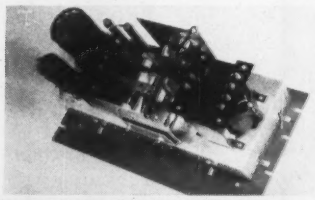


mechanic after flight. Indicator held by eutectic metal is released when heat melts the metal. After use the indicator is reset with a simple turn of the slot. Indictors to react at different temperatures can be supplied. Weight is 0.1 lb.—*Barber-Colman Co., Aircraft Controls Div., Rockford, Ill.*

CIRCLE 248 ON READER-SERVICE CARD

SILICON POWER SUPPLY

New ac-dc full-wave silicon rectifier series for 110 v ac input, 30 v dc output is available in 10, 15 and 20 amp models. Overload capacity is



SPECIAL KEYBOARDS

Any number of keys, bars, switches or lights in any arrangement you require—wired to your specifications.

Concord Keyboards can be found working with many different types of equipment throughout the United States and Canada. Only proven components with exceptionally long life characteristics are used. A typical example: a keyboard that has twelve keys and one bar, wired to a cable and connector with a steel case painted grey—$220. Delivery three to five weeks. Send us a sketch of your desired key layout and wiring specifications for an immediate estimate.

Also call upon us for your special requirements for paper tape or magnetic tape input equipment.

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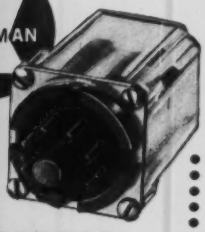
1282 Soldiers Field Road, Boston, Mass.

CIRCLE 130 ON READER-SERVICE CARD

KURMAN

SERIES 26D 10 AMP.



KURMAN
MINIATURE POWER RELAY

FEATURES
- Clear polystyrene dust-proof enclosure
- Up to 3 P D T, 10 amp. contacts
- AC or DC coil, up to 15,000 ohms
- Life—100,000 operations minimum
- Dimensions 1⅜" sq. x 2¼" high
- Octal or 11 pin plug-in

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THERMOCOUPLES
THAT WILL WITHSTAND 2000°F AND UP TO 50,000 PSI

LONG LIFE
Sheath Diameters .04 to .32
Thermocouple Lengths to 50 feet
Complete Thermocouples made to every requirement

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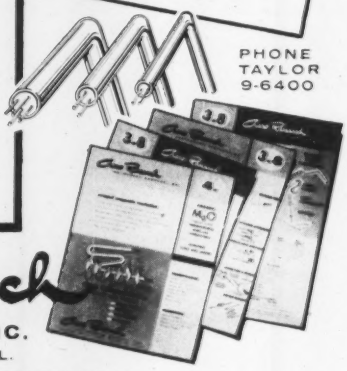
NEW, SIMPLE CONSTRUCTION

Made from metal sheath over ceramic insulated thermocouple wire.

Metal sheath can be bent and weldments can be performed without loss of insulation.

Write for Bulletins → 3.8 for complete thermocouples. 4 for ceramic insulated wire.



PHONE TAYLOR 9-6400

Aero Research
INSTRUMENT COMPANY, INC.
315 NORTH ABERDEEN • CHICAGO 7, ILL.

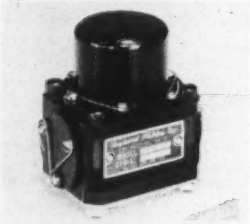
CIRCLE 132 ON READER-SERVICE CARD

400% for ½ min, 200% for 2 min; and flashing light signals when continuous ratings are exceeded on 15 and 20 amp models. Output is isolated from line, and ripple is below 1% within rated voltage and load.—*Gates Electronic Co., 2090 Barnes Ave., Bronx 62, N. Y.*

CIRCLE 249 ON READER-SERVICE CARD

PNEUMATIC SERVOVALVE

New Model 610 four-way pneumatic servovalve ensures reliability by two features: (1) Particles as large as 200 microns are passed without malfunction by first and second

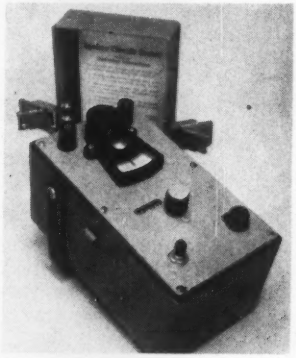


servovalve stages; and (2), first stage cannot become unbalanced by contamination because it has only one source of gas. Hermetically sealed torque motor is "dry" (isolated from the gas). Operating pressure is from 300 to 1500 psi, standard temperature ranges are from −65° to 250°F.—*Raymond Atchley, Inc., 2340 Sawtelle Blvd., Los Angeles 64, Calif.*

CIRCLE 250 ON READER-SERVICE CARD

IGNITER CIRCUIT TESTER

New Model 101-5AF Igniter Circuit Tester, used primarily in field testing of solid fuel rockets such as Polaris, Terrier, Nike, Talos, Honest John, Mighty Mouse, Snark, and air-

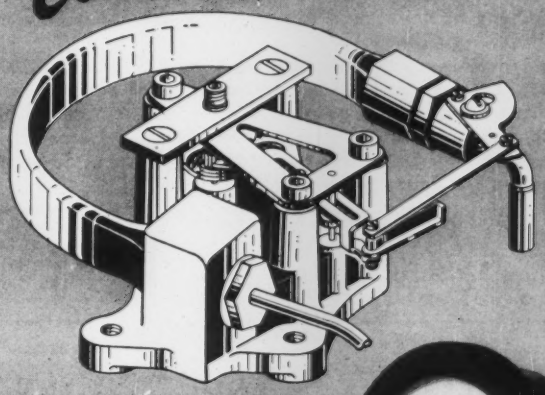


craft JATOs is also valuable in static test facilities. Using only 0.005 amp output, it safely measures igniter circuit resistance to an accuracy of ± 0.05 ohm or better, allowing the user to isolate a fault, which a less accurate instrument cannot do.—*Allegany Instrument Co., 1091 Wills Mtn. Cumberland, Md.*

CIRCLE 251 ON READER-SERVICE CARD

HEISE GAUGES

NEW Automatic Thermal Compensator



Heat and cold have no effect on the Heise High Precision Pressure Gauge equipped with the new Thermal Compensator. (Patent applied for)

Developed by the Heise Laboratories, manufacturers of the world's finest pressure measuring instruments, this unique device now eliminates all error due to thermal variations. Pointer errors caused by linkage growth and changing modulus in the Bourdon Tube are positively and precisely compensated by the equal and opposite action of a scientifically designed and balanced bimetal bar to maintain calibration through a temperature range from 0° to 100°F.

Even exposed to rapidly changing weather outside the confines of the laboratory, the Heise Gauge upholds its traditional position as

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Pressure Ranges 15 to 20,000 P.S.I. Dial Sizes 8½"-12"-16"

Prices from $196.75 DELIVERY WITHIN 30 DAYS

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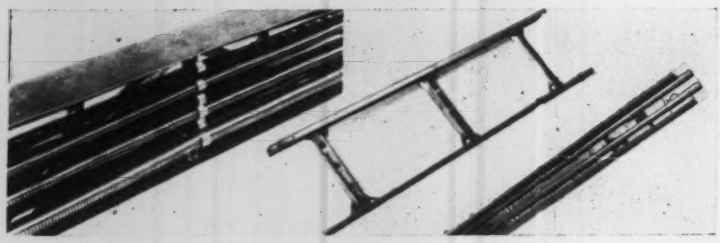

Supports—Expanded and solid metal Trays and Ladder—in *Galvanized Steel* and *Aluminum*, to hold Power and Control Cables and Instrument Tubing. Specified and Approved For All Types of Governmental, Utility and Industrial Jobs.

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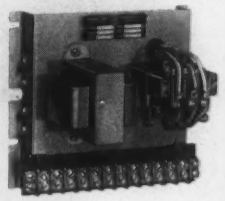
PILOT RELAYS

New PR-Series Pilot Relays are used as single- or dual-level controls (pump in or out); high- or low-level alarm; contact meter amplifiers; liq-



uid leak detectors; or temperature detectors. Features include: (1) No moving parts in the liquid; (2) no stuffing box or bellows; (3) level detection better than 0.10"; and (4) special cable not normally required.—*Webster Electric Co., Racine, Wis.*

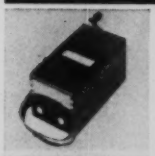
CIRCLE 252 ON READER-SERVICE CARD

METAL-FILM RESISTORS

Newly added Metal Film Resistors in the Vamistor line, Models 9850 (1-watt) and 9849 (2-watt) incorporate the same low temperature coefficient (25 and 50 ppm); tolerances (1, 0.5 0.25 and 0.1%); and extra-high stability offered in the other smaller members of the line.—*Weston Instruments Div., Daystrom, Inc., 614 Frelinghuysen Ave., Newark 12, N. J.*

CIRCLE 253 ON READER-SERVICE CARD

MEGOHMER
INSULATION TESTERS



GENERATOR TYPES

MINOR—Dwarf Size
500V, 50 Megohms

MAJOR—Small Size
Constant Voltage 500V
Megohm & Ohm Scales

STANDARD—Heavy Duty
500/1000V
up to 2000 Megs.

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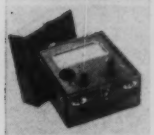
NON-CRANKING

MODEL B-6—0-200 Megs.
2000 Ohms, AC-DC Volts

MODEL B-7—20/200 Megs.
200/20,000 Ohms.



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MODEL P-1 for PRODUCTION TESTING
115V AC line operated
500/1000V
100/1000/2000 Megohms

ELECTRONIC TYPE

20,000,000 Megohms

MODEL 29A with 11 ranges
Range 300,000 to 20,000,000 megohms
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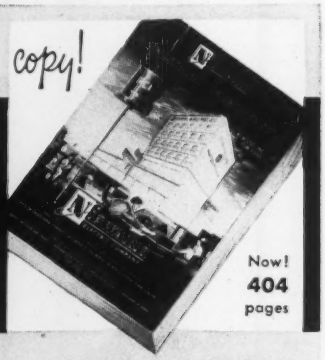

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CIRCLE 136 ON READER-SERVICE CARD

NEW SILICON RECTIFIERS

Fiftyeight new pigtail and stud-mounting types, plus former G. E. types, now provide over 100 low-current alloy-junction silicon rectifier

models. Specification sheets ECG 349 to ECG 353 inclusive cover the new series: 1N332; 1N550; 1N599, 1N599A; 1N607, 1N607A; 1N1100.—*Semiconductor Prod. Dept., General Electric Co., Syracuse, N. Y.*

CIRCLE 254 ON READER-SERVICE CARD

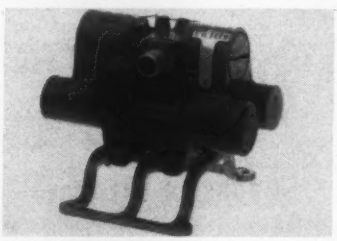
INDICATOR LIGHTS

New twin-lamp Indicator Lights have plastic lenses which can be engraved with words, abbreviations, or entire phrases to denote circuit functions. Three new placard lights are available—the standard Series L5900, the dual-color Series L5910, and a "press-to-test" version, Series L5200. In the L5200, both lamps may be illuminated through separate circuits by pressing on the lens face.—*Hetherington Inc., Folcroft, Penna.*

CIRCLE 255 ON READER-SERVICE CARD

6-WAY, 4-POSITION VALVE

New 6-way, 4-position Solenoid-Operated Selector Valve combines the functions of two separate valves which control the landing gear and landing-gear doors in a 3000-psi,



275°F aircraft hydraulic system. The combination of two valves in one package eliminates 2 solenoids and 2 hydraulic line connections previously required, thereby increasing system reliability and reducing weight.—*Hydra-Power Corp., Pine Court, New Rochelle, N. Y.*

CIRCLE 256 ON READER-SERVICE CARD

FOR MORE INFORMATION ON PRODUCTS REPORTED OR ADVERTISED, CIRCLE CORRESPONDING NUMBER ON READER-SERVICE CARD ON PAGE 1241. IF THE CARD HAS ALREADY BEEN USED, MARK NUMBER AND DATE OF ISSUE ON POSTAL CARD AND SEND C/O OUR READER SERVICE DEPT.

OUTSELLS THEM ALL!

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1 2½ to 1 ratio – guide length to guide diameter–prevents galling and hanging up.

2 High thermal expansion rate of sleeve guide and low thermal expansion rate of hardened stem retainer eliminates binding and galling even at elevated temperatures.

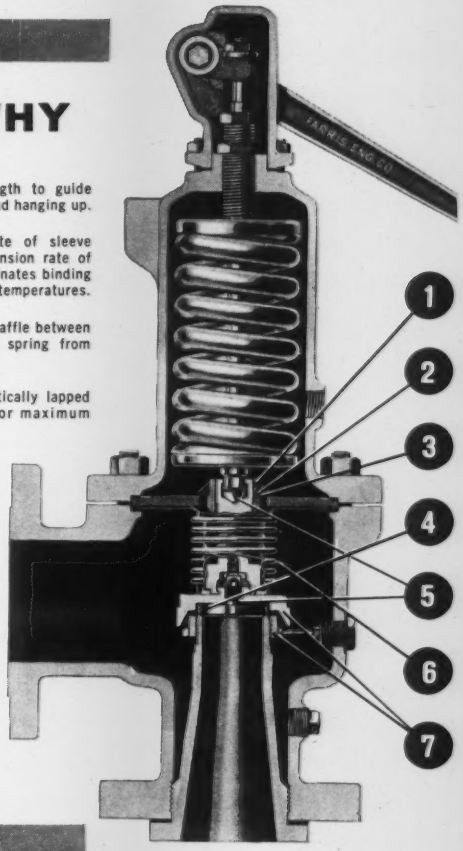
3 Sleeve guide provides solid baffle between body and bonnet, shielding spring from lading fluid.

4 Hardened stainless steel optically lapped flat disc – self aligning for maximum tightness.

5 Double universal ball joint from stem to disc for self alignment – eliminates effects of spring, temperature and piping distortion.

6 Stainless steel "BALANSEAL" bellows nullifies effect of back pressure and isolates internal working parts from lading fluid.

7 Cone-shaped disc holder directs flow away from guiding surfaces and forms fixed secondary orifice with single blowdown ring control for built-in capacity.



Farris full nozzle Safety-Relief Valves

Simplicity in design, safety in operation . . . what more can you ask of a Safety-Relief Valve! The patented design features shown in this Farris valve have been *standard* for more than a decade. It's the ideal concept of a trouble-free, safe, safety valve, free from inventory and design change problems since 1945. It's the *preferred design* in full nozzle safety-relief valves for the process industry.

Detailed information for the selection and sizing of all Farris process safety-relief valves is in Catalog FE-418. Sent to you on request.

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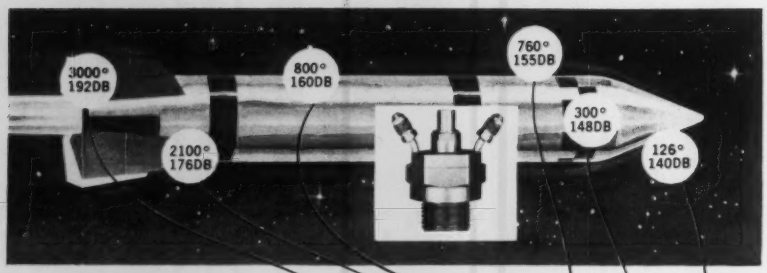

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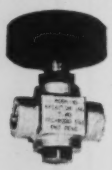

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Remove moisture & oil vapor from gases with working pressures up to 12,000 PSI; dew points - 100°F.

CIRCLE 139 ON READER-SERVICE CARD

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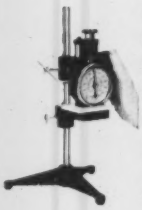
SCLEROSCOPE
FOR TESTING THE HARDNESS OF METALS. PIONEER AMERICAN HARDNESS STANDARD. OVER 40,000 IN USE.



DUROMETER
FOR TESTING THE HARDNESS OF RUBBER & RUBBER-LIKE MATERIALS
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(ASTM D1484)

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90-35 VAN WYCK EXP.
JAMAICA 35, N. Y.

CIRCLE 140 ON READER-SERVICE CARD

LOW-OHMMETER

New hand-size Low-Ohmmeter, Model 3C8, featuring scale length of $\frac{3}{8}$" to the 0.1-ohm position, is made with ranges of 0-50, 0-500, 0-5000 ohms.

Other features are: Ohms adjust knob on side of case to compensate for variations in battery voltages, and meter-bar-ring design, self-shielded, 1 ma full scale.—*Triplett Electrical Instrument Co., Bluffton, Ohio.*

CIRCLE 257 ON READER-SERVICE CARD

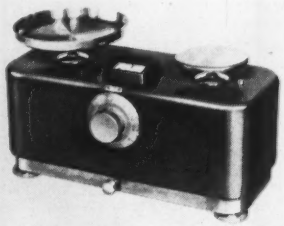
DATA PRINTERS

New Tracer/Matic series of Data Printers includes the Auto/Printer (SC-87) which furnishes a printed tape containing sample number elapsed time and total counts; and the SC-88, Auto/Computer which prints this same information and, in addition, computes and prints the count rate (counts/min) of each sample. By using the Auto/Printer or the Auto/Computer, practical automation in nuclear presentation is obtained.—*Tracerlab, 1601 Trapelo Rd., Waltham 54, Mass.*

CIRCLE 258 ON READER-SERVICE CARD

TORSION BALANCE

New Dial Laboratory Balance, Model DLT5, featuring a simple graduated dial which can be turned without arresting the oil-damped balance, is



said to save 60% of weighing time. Dial is graduated from zero to 10 grams by one-tenth (0.1) gram graduations and is readable to 0.02 gram. —*Torsion Balance Co., Clifton, N. J.*

CIRCLE 259 ON READER-SERVICE CARD

ENCODER

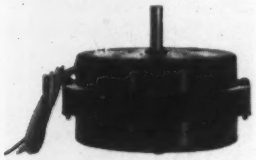
New Model PH-VII-1 Optisyn Encoder, with a built in buffer amplifier, reduces the number of required signal leads to 4 and increases the

voltage of the output signal. It features high readout rate, small size, and long life. Resolution is 2048/rev; maximum speed is 3000 rpm. Meets MIL Std 202A.—*Dynamics Research Corp., 44 Winn St., Woburn, Mass.*

CIRCLE 260 ON READER-SERVICE CARD

HYSTERESIS MOTOR

New 1/300-hp Hysteresis Motor, Model HMB, features low heat-rise rate, absolutely synchronous opera-

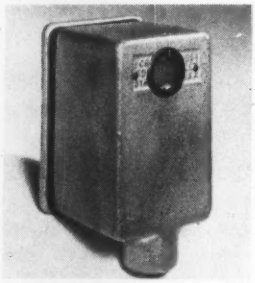


tion, high starting torque, and a capacitor two or three times smaller than any other hysteresis motor. This reduces motor plus capacitor cost.—*Dale Products, Inc., Columbus, Neb.*

CIRCLE 261 ON READER-SERVICE CARD

WEATHERPROOF PHOTORELAY

New Model R-CH Photorelay uses a solid-state photocell to trigger on-off and go-no-go circuits automatically at predetermined light levels. It



is sensitive to 10 foot-candles. Mounted in a Crouse-Hinds FD-1 Condulet box with a ½" threaded fitting, this simple light-sensing control withstands the effects of dust, moisture, shock, vibration and other adverse environmental conditions.—*Berkeley/Dynamics, 2831 Seventh St., Berkeley, Calif.*

CIRCLE 262 ON READER-SERVICE CARD

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- ***Resolution: 1 part in 10,000***
- **LABORATORY PRECISION for the operating plant.**
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Accuracy to ±5 seconds

Any scale pattern—Any line width—Any material

FINE MACHINE ENGRAVING
Scales, Dials, Drums, Rods, Panels
ACCURATELY ETCHED RETICLES
Made to any specified pattern and dimensions

PROMPT DELIVERY
on large or small quantities.

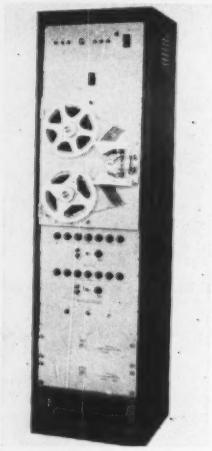
L. C. RENICK CO.
308 So. Salsipuedes St., Santa Barbara, Calif.
formerly Chicago, Illinois

CIRCLE 144 ON READER-SERVICE CARD

NEW INSTRUMENTS

MAGNETIC TAPE TESTER

New fully-transistorized Model 3298 Magnetic Tape Tester automatically locates and indicates tape flaws that may be classified as noise or drop-out. Residual signals on the tape

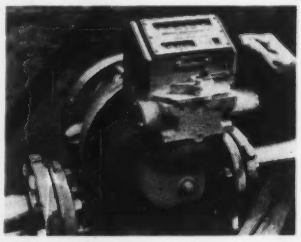


are detected with a separate playback head, after passing over an erase head. Similar logical circuitry is associated with the noise test. Tape speeds up to 150"/sec and pulse densities to 550/in can be accommodated with tape widths from ½" to 1" on 10½" reels.—*Potter Instrument Co., Inc., Plainview, N. Y.*

CIRCLE 263 ON READER-SERVICE CARD

IN-LINE ROTOCYCLE METER

New 2S petroleum and industrial Rotocycle Meter, with a special in-line steel case, does not need a manifold or 45° elbows when used on horizontal piping lines. Although designed for



"lease automatic custody transfer systems" (LACT) it has applications in the food, chemical, petro-chemical, pharmaceutical, and industrial processing fields. Features include—direct rotary flow, liquid capillary seals, low friction construction and minimum flow resistance, a variable speed device, and a Teflon shaft seal.—2-page Bulletin OG-415 contains details.—*Rockwell Mfg. Co., Meter and Valve Div., 400 North Lexington Ave., Pittsburgh 8, Pa.*

CIRCLE 264 ON READER-SERVICE CARD

NEW!

COMPACT ELECTRIC IMPULSE COUNTER PRINTS AS WELL AS INDICATES

SODECO Print Counter Provides Permanent Records.

Measuring only 2⅞" x 5⅝" x 7-3/16", the new **SODECO** Print Counters offer all the accuracy and reliability of conventional **SODECO** counters with the added feature of a printing mechanism to provide a permanent record of the count at any given time.

The counters indicate pulse count to 6 digits and can be supplied with mechanical and electric zero reset. The count can be registered on the paper tape or inserted card manually or by remote command. Models are available which print the day, month, and hour in addition to the count, for permanent logging.

See a demonstration of the SODECO Print Counter at Booth 219 at the Instrument Show, or write to us for complete details

LANDIS & GYR, Inc.

45 West 45th Street **New York 36, New York**

CIRCLE 145 ON READER-SERVICE CARD

For Accurate TEMPERATURE RECORDS at MODERATE COST

RANGES AVAILABLE	
Temperature Range	One Rotation of Chart
−30° to +120°F.	7 Days
−30° to +120°F.	24 Hours
−30° to + 50°F.	24 Hours
−20° to + 40°F.	7 Days
−10° to + 50°F.	24 Hours
−10° to + 50°F.	24 Hours
10° to 90°F.	24 Hours
30° to 60°F.	7 Days
40° to 100°F.	24 Hours
40° to 100°F.	24 Hours
50° to 130°F.	24 Hours
60° to 90°F.	24 Hours
60° to 90°F.	8 Hours
70° to 130°F.	24 Hours
−25° to + 10°C.	24 Hours
5° to 40°C.	24 Hours

Use TEMPSCRIBE Recorders

BULB-TYPE (illustrated)—*For recording temperatures at a distance*
BI-METAL TYPE—*For recording temperatures in surrounding air*

- Portable—easily carried. Can be set on flat surface or hung on wall.
- Spring-wound instrument-type clock: 3 standard movements—8 hours, 24 hours or 7 days.
- Instrument measures 4½" x 5½" x 7½"; uses 4¼" diameter charts.
- Chart graduations easy-to-read; spaced uniformly over full range.
- Pen and its actuating components are in door. Doors are completely interchangeable to convert to any temperature range, or from bi-metal type to bulb-type.

Also available: (1) Interchangeable door with electro-magnetic armature to record running time of motors, burners, solenoid valves, etc. (2) Two-pen doors for recording temperature and electrical operation on same chart.

Write for Leaflets 786 and 872

BACHARACH INDUSTRIAL INSTRUMENT CO.
200 N. BRADDOCK AVE. • PITTSBURGH 8, PA. T-25

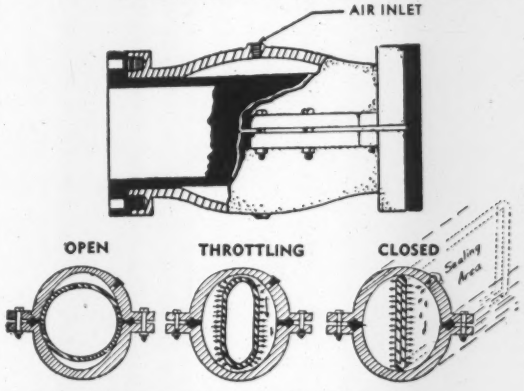
CIRCLE 146 ON READER-SERVICE CARD

See the

RED JACKET VALVE

for handling solids in suspension

In Booth 860 at the Instrument-Automation Show



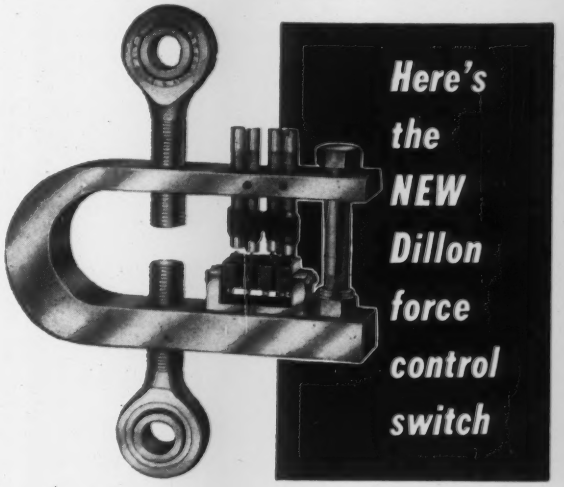
1. Only one wearing part, the rubber sleeve
2. Unobstructed streamline flow characteristics
3. Sleeve forms around entrapped material for positive seal
4. Valve has built in operator

or send for catalog

RED JACKET COMPANY, INC.

500 Bell Avenue Carnegie, Penna.

CIRCLE 147 ON READER-SERVICE CARD



- 6 Different Ranges: From 0-100 lbs. up to 0-50,000 lbs.
- Triggers motors, rings bells, operates warning devices, etc.
- Protected against accidental overloading.
- Tensile or Compression Models available.
- Furnished with from 1 to 4 adjustable switches for controlling forces at various load points.
- Can be set for most critical accuracy.

WHAT CAN IT DO FOR YOU?
Write for specifications, profusely illustrated literature and low price schedule . . . free!

W. C. Dillon & COMPANY, INC.

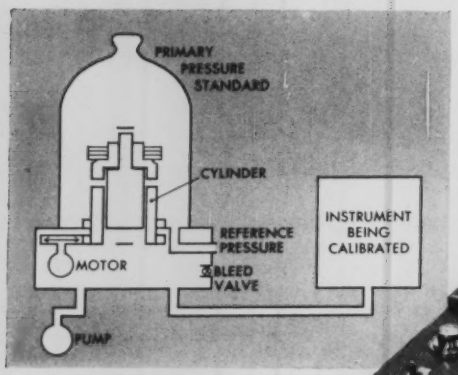
14584 Keswick St.
Van Nuys 13, Calif.

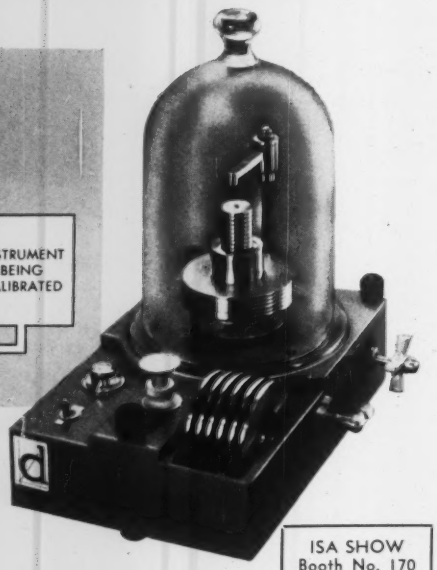
CIRCLE 148 ON READER-SERVICE CARD

a giant step forward in accurate pressure measurement . . .

NEW! PRIMARY PRESSURE STANDARD

features cyclic bi-directional rotation





Dynametrics Primary Pressure Standard measures pressures from 0.2 psi absolute to 500.0 psi gauge.

ISA SHOW
Booth No. 170

With the Dynametrics Primary Pressure Standard, calibration is achieved by simply balancing known weights applied to a known area against an air pressure system that is common to both the instrument under test and the Primary Pressure Standard. Any pressure measuring instrument can be calibrated from *0.2 psi absolute to 500.0 psi gauge with a measuring accuracy of 0.015% of range.*

The newly developed Dynametrics Primary Pressure Standard provides *exclusive* cyclic bi-directional rotation of the cylinder to average out rotational lift error due to helical orifice effect, minimize friction, and eliminate eccentric force application to piston-weight unit. Accuracy is further assured by maintaining micro-inch tolerances in the production of weight sets and piston-cylinder assemblies. Power requirements are 105-124 volts, 60 cps, 12.5 watts.

FEATURES

- Four pressure ranges
  0.2-15 psi (increments of 0.1 psi)
  0.5-50 psi (increments of 0.5 psi)
  1-150 psi (increments of 1 psi)
  5-500 psi (increments of 5 psi)
- Pressure connection to bell jar chamber allows use of any reference pressure from zero to one atmosphere absolute.
- Three leveling screws and bubble level for easy leveling.
- Built-in pressure bleed valve.
- Self-contained, convenient filtered pressure source provides up to 15 psi.
- Two pressure connections to the measuring chamber for convenience.

PRICE

Basic Unit, Model PPS-500	$695.00
Either Low- or High-Range Piston-Cylinder Assembly	350.00
Unit Weight Set, or 5X Weight Set	350.00
	$1395.00

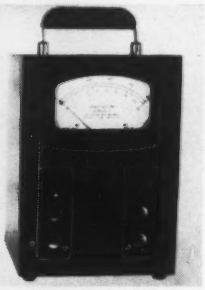
Write for Technical Bulletin on Primary Pressure Standards.

DYNAMETRICS CORPORATION
Northwest Industrial Park • Dept. 18 • Burlington, Massachusetts

CIRCLE 149 ON READER-SERVICE CARD

TEMPERATURE INDICATOR

New Model PI-3, a Dual-Range Precision Temperature Indicator for use with any 100-ohm resistance probe or



a thermometer using CP nickel wire, is portable, battery-operated, and direct-reading. The standard model has a low range of −60°F to +140°F and a high range of 0°F to +500°F. Readability on the low range is within 1°F.—*Arthur C. Ruge Associates, Inc., Hudson, N. H.*

CIRCLE 265 ON READER-SERVICE CARD

MOTOR DRIVE AMPLIFIER

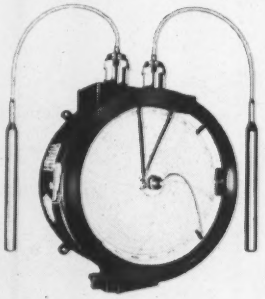
New MDA-Series Motor Drive Amplifier, designed primarily to provide precise 60-cps power for tape re-

corder motors, is available for operation from either 24-28 vdc or 105-125 vac, 48-62 cps. Output is 100 w with frequency regulation of ±0.02%. —*Precision Instrument Co., San Carlos, Calif.*

CIRCLE 266 ON READER-SERVICE CARD

DUAL RECORDING THERMOMETER

New Dual Recording Thermometer, Model TRH, records temperatures up to 1100°F from two thermal sensing



elements. The two pens operate on a two-hour differential to prevent any possible interference in case both sensed temperatures happen to be the same.—*Partlow Corp.*, 525 *Campion Rd., New Hartford, N. Y.*

CIRCLE 267 ON READER-SERVICE CARD

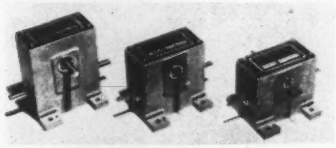
Spotlight on Space!

LEVELING SQUARES

New types of Leveling Squares of

SPEED REDUCERS

New line of Precision Speed Reducers, with ⅛", $\frac{3}{16}$" and ¼" shafts is designed for torques up to 350 in-oz in ratios from 1:1 to 360:1, and

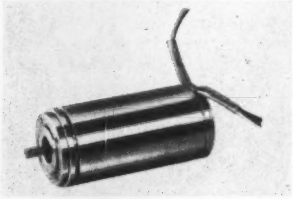


features precision ball bearings or oilless bronze bearings. A complete range of over 175 different sizes and ratios are available from stock, for immediate delivery.—*PIC Design Corp.*, 477 *Atlantic Ave., East Rockaway, L. I., N. Y.*

CIRCLE 268 ON READER-SERVICE CARD

MOTOR TACH GENERATOR

New Size-15 temperature-compensated Motor Tach Generator, Type 6280-05, incorporating a 4-pole, 115-v fixed-phase motor with a 36-v control-

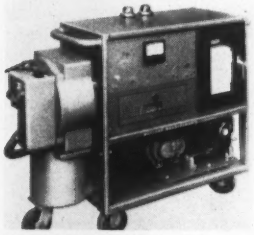


phase center-tapped winding, suitable for transistorized operation, has stall torque 1.5 in-oz and no-load speed 9500 rpm. Meets MIL-E-5272.—*John Oster Mfg. Co., Avionic Div.*, 1 *Main St., Racine, Wis.*

CIRCLE 269 ON READER-SERVICE CARD

MOBILE AIR MONITOR

New Air Monitor AM-3A features four interchangeable detectors, to sense any of four combinations of radioactivity—(1) alpha, beta, and gamma, (2) beta-gamma, (3) alpha, or (4) beta. Most sensitive detector

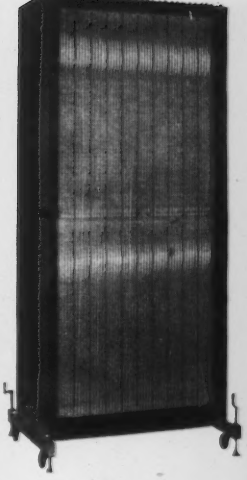


is Model FGM-1, designed for sensing alpha, beta, and gamma radiation instantaneously, without radiation discrimination. It consists of a 2" hemisphere gas-flow Geiger detector with 1 mg/cm²-thick mylar window. An all-transistorized amplifier is built as part of the probe. Unit is mounted on mobile cart.—*Nuclear Measurements Corp.*, 2460 *North Arlington Ave., Indianapolis* 18, *Ind.*

CIRCLE 270 ON READER-SERVICE CARD

From: *small single tube standard manometers with scale heights from 6" to 100" . . .*

To: *large multiple photopanel units providing maximum utility in minimum space . . .*



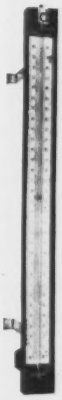
ISA SHOW
Booth No. 170

DYNAMETRICS MANOMETERS FOR EVERY PURPOSE

Dynametrics provides a wide range of standard inexpensive pressure measuring instruments designed for a variety of laboratory, testing, and industrial uses where accuracy is a primary consideration.

These instruments incorporate all the precision standards required in the laboratory, yet are built to withstand the unavoidably rough handling of industrial application. With Dynametrics Manometers, a high degree of accuracy and reproducibility of process conditions can be achieved — at a significantly low cost. Special panels and test stands can be made to meet your requirements.

2 New Manometers Uniquely Compatible with Every Manometer Fluid . . . Wetted Parts Consist of Pyrex, Stainless Steel, Non-deteriorating Seals



MODEL S MANOMETER

Available in 13 scale heights from 6" to 100", this low-cost precision built instrument permits accurate pressure measurement in a variety of industrial applications. Seals and wetted parts will not corrode in the presence of mercury, water, TBE, or hydrocarbon-based fluids. Model S is lightweight, rugged, and portable, permitting it to be taken right to the job.

MODEL U MANOMETER

Designed for accurate measurement of differential pressures at low cost. Available in 8 models with scale heights from ±3" to ±25", this inexpensive, ruggedly built instrument is applicable to many uses in plant or field. Can be used with all manometer fluids. Corrosive fluids will not harm seals or wetted parts. Model U is portable and quickly put into operation.

Write for "Manometers – theory and application"

DYNAMETRICS CORPORATION

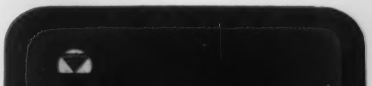
Northwest Industrial Park • Dept. 18 • Burlington, Massachusetts

CIRCLE 150 ON READER-SERVICE CARD

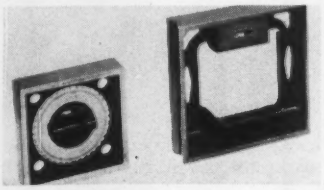
A LOT OF CONTROL IN A SMALL

CHROMATOGRAPHY

New Chromatofuge, Model 5060, designed by Hugh J. McDonald, de-



New types of Leveling Squares of Swiss precision make include (1) the Solid Square which is available in 3 degrees of sensitivity: 3, 5, and 10 sec



of arc with range limited to that of the bubble tube, namely ± 7 intervals, and (2) a simplified and inexpensive Clinometer, with a range of 0-180-0° and vernier reading in 6 min of arc. The inherent accuracy is 30 sec of arc.—*Opto-Metric Tools, Inc.*, 137 *Varick St., New York* 13, *N. Y.*

CIRCLE 271 ON READER-SERVICE CARD

KLYSTRON POWER SUPPLY

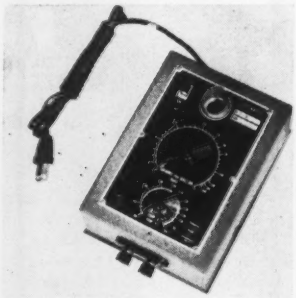
New Model 438 Wide-Range Klystron Power Supply can be used with most medium- and low-voltage klystrons, as well as some of the high-voltage units (with reduced power

output). Extremely stable in operation, the unit provides beam-voltage range of 250 to 750 ± 1 v for 105-125 vac, and 0 to 65 ma with a maximum ripple of 5 mv. Load regulation over 3 ranges, with 20-v overlap, is ± 3 v, for 0 to 65 ma.—*Narda Microwave Corp.*, 118-160 *Herricks Rd., Mineola, N. Y.*

CIRCLE 272 ON READER-SERVICE CARD

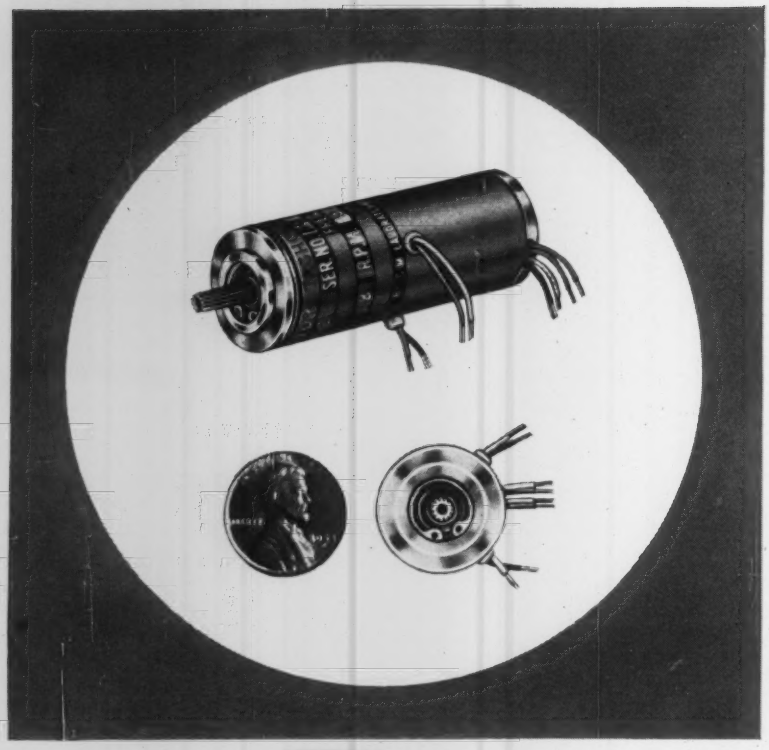
PURE-WATER MONITOR

New Model RD-A146 SoluBridge for monitoring highest-purity water is calibrated 0.05 to 1.0 micromho/cm



specific conductance at 25°C and has temperature compensation for 5 to 35°C. The unit is available as indicator, or as controller.—*Industrial Instruments, Inc.*, 89 *Commerce Rd., Cedar Grove, N. J.*

CIRCLE 273 ON READER-SERVICE CARD



NEW GM SIZE 8 MOTOR GENERATOR

for transistor operation

Tested to conform to all applicable Government Specifications for humidity, salt-spray, temperature, altitude, vibration! Promptly available in prototype and sample quantities.

- Outside Diameter: 0.750 inches.
- Weight: 2.9 ounces maximum.
- Tachometer-generator operates on 18 volts, 400 cycles.
- Gradient: 0.23 volts per 1000 RPM.
- Maximum null voltage: 0.015 RMS.
- Both fixed and control phase of motor wound for 18 volts, 400 cycles.
- Stall Torque: 0.3 ounce-inch, with no-load speed of 5400 RPM.
- Pinion Data: Precision Class 2, 13 tooth, 120 pitch, 20° pressure angle.

GM

G-M Servo Motors

manufactured by the Components Division of

G-M LABORATORIES INC.

4316 N. Knox Avenue • Chicago 41

Write for full information, G-M Recommended Procurement Specification No. 665 and Catalog.

CIRCLE 151 ON READER-SERVICE CARD

GOLAY COLUMN/IONIZATION DETECTOR SYSTEM

New unit comprising a Golay Column, an Ionization Detector, and an

IN A SMALL SPACE

DAHL
"BANTAM"
VALVES

Dahl "Bantam" 2020, 2030 and 2031 series are highly compact, diaphragm-operated on-off valves. Each features the desired ruggedness and high quality of larger valves, and yet, allows appreciable savings in space. All have cast globe bodies for steam, liquid or gas applications.

"Bantam" valves have excellent flow characteristics, low hysteresis and fast response. Use of TEFLON® packings eliminates frequent packing adjustment and greatly reduces maintenance.

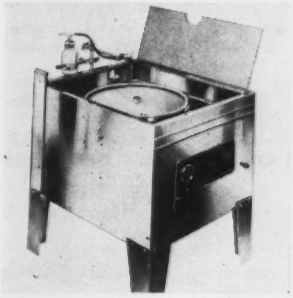
MAXIMUM Cv	40.0
LIFT	⅝"
SEAT AREA	up to 3.1 sq. in.
CONNECTIONS	¼" to 2" N.P.T.
PRESSURE RATING	150 psi for steam 300 psi for liquid & gas
OPERATORS	8, 15, 50 sq. in.

For more detailed information on "BANTAM" On-Off and Throttling Control Valves write for . . . . . Catalog B-1.

GEORGE W.
DAHL
COMPANY, INC.
86 TUPELO STREET, BRISTOL, RHODE ISLAND

CIRCLE 152 ON READER-SERVICE CARD

New Chromatofuge, Model 5060, designed by Hugh J. McDonald, delivers more accurate differential sep-

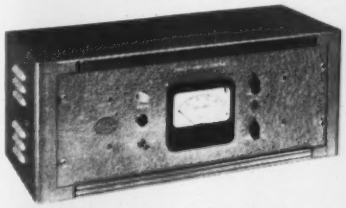


arations of amino acids, steroids, hypoproteins, selected dyes, etc. in only 15 to 20 min instead of several hours formerly needed with classical methods. Multiple separations can be run simultaneously.—*Labline, Inc.*, 3070-82 *W. Grand Ave., Chicago* 22, *Ill.*

CIRCLE 274 ON READER-SERVICE CARD

CAPACITY-SENSITIVE CONTROL

New Capacity-Sensitive Control for laboratory processes, is based on detection of minute capacity changes

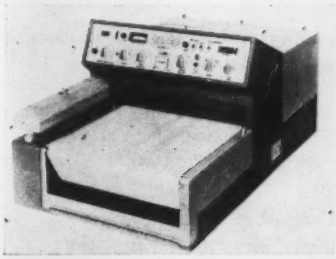


as encountered in the rise or fall of manometers, thermometers, barometers, floats, in flowmeters or precise mechanical movements.—2-page bulletin gives details.—*H. S. Martin & Son,* 1916 *Greenleaf St., Evanston, Ill.*

CIRCLE 275 ON READER-SERVICE CARD

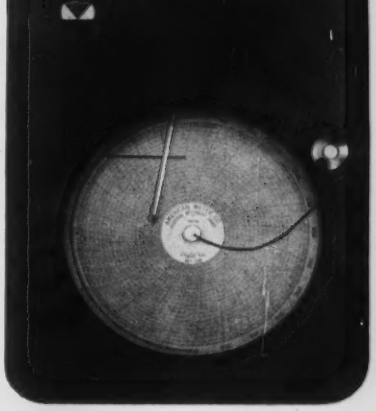
READOUT OSCILLOGRAPH

New Model 603 Oscillograph, recording up to fifty channels of test data on a 12" wide record, uses light-



beam type galvanometers with accurate response up to 6000 cps, and the direct writing process with a trace-writing capability in excess of 30,000"/sec.—*Midwestern Instruments, P. O. Box* 7186, *Tulsa, Okla.*

CIRCLE 276 ON READER-SERVICE CARD



AMERICAN®
PRESSURE
and
TEMPERATURE
RECORDERS

American® single and two-pen *Pressure Recorders* for pressures from 30 inches vacuum to 10,000 psi.

- Pressure elements individually calibrated over full range.
- Variety of chart drives available.
- Helical elements of different ranges are interchangeable.
- Stainless steel pen arms with span and linearity adjustments.
- Aluminum dust and moisture-proof case.

American® *Temperature Recorders* for an accurate record of flowing temperatures.

- No ambient temperature errors.
- High sensitivity and torque—fast speed of response.
- Standard 0-150°F. range. Other ranges available by request.
- 24-hour mechanical or 110-v. 60-cy. electric chart drives.

Ask for Bulletins 400 and 408

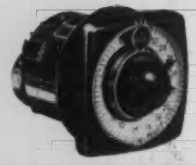
AMERICAN®
METER COMPANY
INCORPORATED (ESTABLISHED 1836)
General Offices: Philadelphia 16, Pa.
Sales Offices in Principal Cities

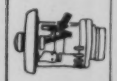
CIRCLE 153 ON READER-SERVICE CARD

HANDY SELECTION GUIDE GIVES ROTAMETER SPECIFICATIONS

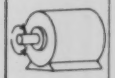
writing, optional plug-in remote controls, and individual micrometer adjustments for accurate pen alignment

Unmatched versatility



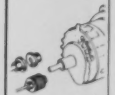


SERIES 305—Controls up to 6 individual load circuits; easily changed from "Reset" to "Non-Reset."



SERIES 306—Controls 2 separate adjustable load circuits; built-in dwell protects reversing motors.

SERIES 304—Integral "On-Off" control eliminates need for separate switch.



SERIES 307—Revolution Counter; permits direct connection to flexible cables, differential couplings, gears, rotating shafts.

TIMERS FOR AUTOMATIC CONTROL

ACCURATE . . . RUGGED . . . TIME SPLIT SECONDS OR HUNDREDS OF HOURS

Now you can order off-the-shelf timers for every industrial control application, including highly complex control functions involving hundreds of timed or sequential operations. ATC offers the widest line of standard timers, plus complete design and engineering assistance to meet special requirements. These unique features mean more dollar value from ATC timers:

Easy one-hole mounting in standard 3 3/16" cut-out. **Fully insulated ring clamp replaces screws.**

Change cycle any time with handy large knob. **Cover slips off without disconnecting timer from service.** **One piece rolled cover has integral printed wiring schematic.**

Write now for new illustrated Condensed Catalog; contains complete specifications and performance data.

atc

AUTOMATIC TIMING & CONTROLS, INC.

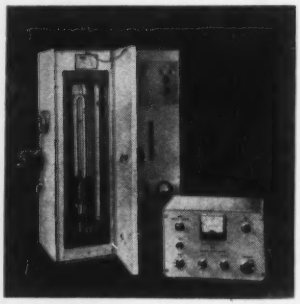
KING OF PRUSSIA, PENNSYLVANIA

A SUBSIDIARY OF SAFETY INDUSTRIES, INC.

CIRCLE 154 ON READER-SERVICE CARD

DETECTOR SYSTEM

New unit comprising a Golay Column, an Ionization Detector, and an Amplifier for use with Models 154B and 154C Vapor Fractometers pro-

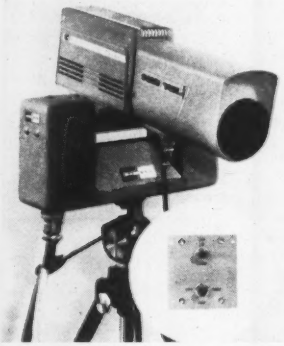


vides resolution said to have been impossible heretofore with conventional packed columns and thermal-conductivity detectors. It comes with two types of detectors: (1) the Flame Ionization Detector which uses nitrogen as the carrier. (2) Beta-Ray Ionization Detector, in which metastable argon atoms (argon is the carrier) are produced by the impact of accelerated electrons from a Krypton 85 radioactive source.—*Perkin-Elmer Corp., Norwalk, Conn.*

CIRCLE 277 ON READER-SERVICE CARD

TV-CAMERA MOUNT

New Pan-Tilt Units, Models ARC-12A and ARC-12B, for TV systems consist of two fhp motors which drive



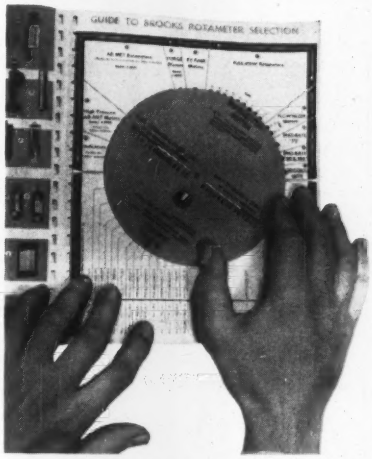
the tilt table and control panning, respectively, also the entire assembly from 0° to 355° in a horizontal plane. —*Kin-Tel Div., Cohu Electronics, Inc., Box 623, San Diego 12, Calif.*

CIRCLE 278 ON READER-SERVICE CARD

12-CHANNEL RECORDER

New plug-in 12-Channel Recording System, BSA-1200, furnishing a true rectilinear trace using ink as the writing medium, records phenomena in the d-c to 200 cps frequency range. System features 18 push-button chart speeds, event marker and synchronous timer, easy conversion to electric

ROTAMETER SPECIFICATIONS WITH JUST A TURN OF A DIAL



It's yours for the asking . . . from Brooks

Here is a quick, convenient way to compare rotameter specifications to find the correct model for any particular application.

With the Brooks Rotameter Selection Guide, you can determine essential information at a glance. You simply set the chart dial at the required flow range, and other pertinent data — model, size, maximum operating temperature and pressure — are conveniently presented.

The Guide covers the full line of Brooks Rotameters . . . a line that includes everything from rugged armored meters for large flows, high temperatures and pressures, to "miniature" purge meters for small flow indication.

All in all, you'll find the Selection Guide a genuinely useful reference manual. To get a copy, request Bulletin 110.

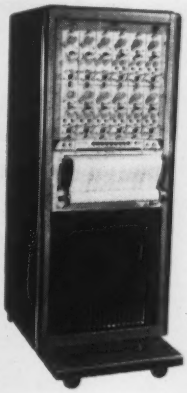
BROOKS ROTAMETER COMPANY

859 J STREET
LANSDALE, PA.

S.A. 1938

CIRCLE 155 ON READER-SERVICE CARD

trols, and individual micrometer adjustments for accurate pen alignment

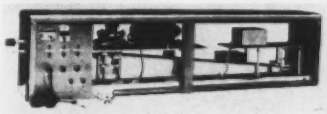


on both the lateral and longitudinal axes.—*Massa Div., Cohu Electronics, Inc., 5 Fottler Rd., Hingham, Mass.*

CIRCLE 279 ON READER-SERVICE CARD

PRESSURE TESTER

New Dead-Weight Pressure Tester indicates automatically pressures to 1,000 psig with accuracy of 0.03 over

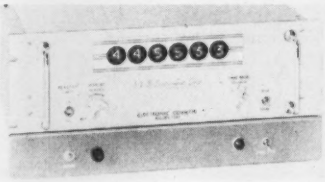


the total range of the instrument. Instrument is suited for research, testing and quality-control projects that require precision pressure measurement for either absolute or differential applications.—*Ideal-Aerosmith, Inc., 3913 Evans Ave., Cheyenne, Wyo.*

CIRCLE 280 ON READER-SERVICE CARD

ELECTRONIC COUNTERS

New Model 1300-Series of Electronic Counters comprises 10 models with a wide combination of facilities: Time bases with fixed selectable times of



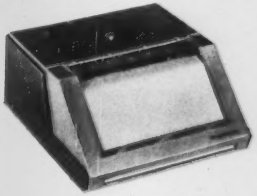
0.1, 0.5 and 1.0 sec; fixed special time bases and preset variable time bases, single and multiple channel; crystal and tuning fork standards; countdown time base; input: sine waves, 5 to 150,000 cps; pulses, 0 to 150,000 cps; accuracy: ± 1 count. Display time is adjustable from 0.1 to 10 sec. Sensitivity is 50 mv rms (5 mv optional). Input impedance is 1 megohm. —*I-L-S Instrument Div., Meriam Instrument Co., 4536 West 160th St., Cleveland 35, Ohio*

CIRCLE 281 ON READER-SERVICE CARD

Unmatched versatility with PHOTRON OSCILLOGRAPHS and AMPLIFIERS

OSCILLOGRAPHS

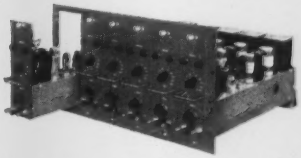
Rectilinear recording with ink or heated stylus. **Curvilinear** recording with ink or electric stylus. AC or DC* chart drive. Frequency response from DC to 150 cps.



Up to 8 channels.
Portable or rack mounted.

NEW Operational Amplifier

Chopper stabilized with feedback attenuation. Single units or modules of 6.



Fixed gain settings from *unity* to 1000.

General Purpose Amplifiers

DC, Chopper Stabilized, and Carrier amplifiers for use with any direct-writing galvanometer or for general laboratory use. Gains from 25 to 10,000. Frequency response from DC to 50kc. *Request Bulletin 210.*

NOW AVAILABLE:

Transistorized galvanometers with voltage gains up to 10, and current gains up to 1000. The use of silicon transistors assures good temperature stability. *Request Bulletin 220.*

*for airborne recording

PHOTRON INSTRUMENT COMPANY

6516 Detroit Ave. • Cleveland 2, Ohio

CIRCLE 156 ON READER-SERVICE CARD

Varian STRIP CHART Recorders

Unique combination of performance, size and price

OVER 1000 TIMES AS SENSITIVE as galvanometer recorders . . . and Varian's null-balance potentiometer needs no power from the source being measured. Rugged, stable mechanism allows ink or inkless recording—easy-to-read rectilinear chart—source impedances of up to 100,000 ohms.

LESS THAN HALF AS WIDE as a standard 19-inch rack. Two Varian G-11A's mount side by side on a rack panel 10⅜ inches high. Or as a portable, the G-11A is an easy-to-handle 15 pounds. The G-10 sits on less than one square foot; its horizontal chart is handy for jotting notes.

MORE VERSATILE AND ADAPTABLE than any similar recorder — adjustable zero, adjustable span (from 9 to 100 mv on the G-11A), multiple chart speeds (up to four on the G-11A), and plug-in input chassis for different recording requirements.

PRICES THAT BEGIN AT $365 for the G-10 and $470 for the G-11A. Because unneeded performance costs money, Varian has intentionally designed for 1% limit of error and 1-second balancing time. Thus, Varian provides needed ruggedness, dependability and operating features at moderate cost.

FOR COMPLETE SPECS. AND STANDARD OPTIONS, WRITE INSTRUMENT DIVISION.

VARIAN associates
PALO ALTO 27 CALIFORNIA

CIRCLE 157 ON READER-SERVICE CARD

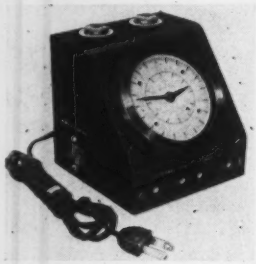
FLOW TUBE METER

New Flow Tube Meter for measuring flow of air; gas; water, oil or other liquids; or steam, through ducts, or piping of any diameter; employs either mercury or oil, and is made with 10", 12", 20" or 30" scales. Accessories available are needle valve equalizer fittings for differential static pressures above scale range, and orifice flanges with adjustable orifice plates.—*Ellison Draft Gage Co., Inc., 548 W. Monroe St., Chicago 6, Ill.*

CIRCLE 282 ON READER-SERVICE CARD

LABORATORY STOP CLOCKS

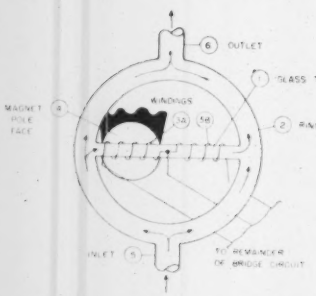
New line of Laboratory Stop Clocks features a timed outlet on the front panel which is energized whenever the clock is timing. This permits the automatic timing of any 115-v, 60-cps load up to 3 a. Two basic models (standard and deluxe) are offered.—2-page Bulletin ET-702 gives details.—*A. W. Haydon Co., Waterbury, Conn.*



CIRCLE 283 ON READER-SERVICE CARD

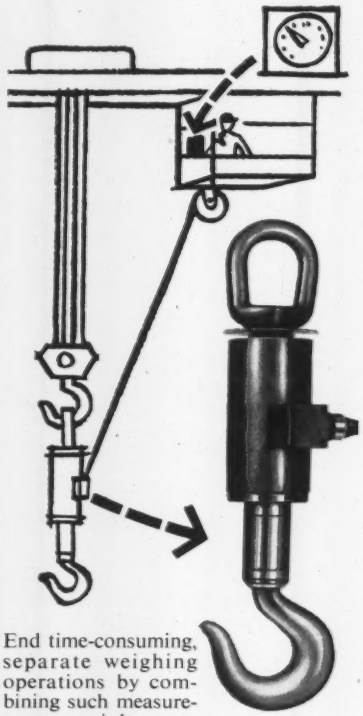
OXYGEN ANALYZER

New paramagnetic-type Low Range Oxygen Analyzer, Model 632, is available in three ranges; 0 to 1%, 0 to 2%, 0 to 3%. Not affected by H_2 concentrations up to 50%, it is sensitive to changes as low as 0.01% oxygen,



MEASURING WEIGHT?

Save handling time with easy-to-install, remote-indicating SR-4® Crane Scales



End time-consuming, separate weighing operations by combining such measurements with your normal materials handling program. SR-4® Crane Scales provide you with accurate inventory control information —on remote dial or printer type indicators—while materials are being moved. SR-4® Crane Scale sensing elements contain no moving parts; require no maintenance; and are unaffected by dirt, grease, water or corrosive fumes. Connection to indicator consists of only a light, flexible electrical cable. Accuracies guaranteed to ±0.2% of capacity. Available for immediate delivery in various capacities from ½ through 25 tons.

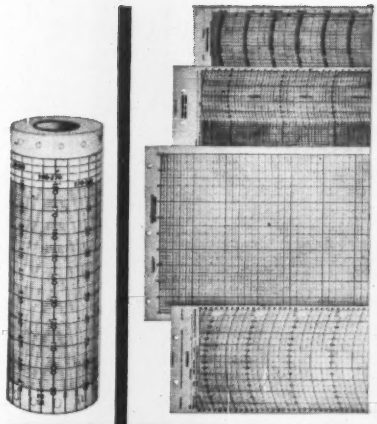
For 12-page Bulletin No. 4513 write Dept. 7-H

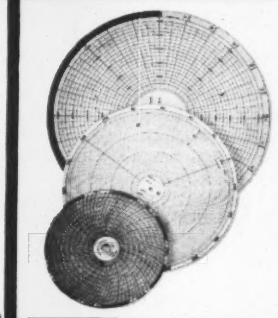
FIRST in force measurement

SR-4 BLH BALDWIN LIMA-HAMILTON

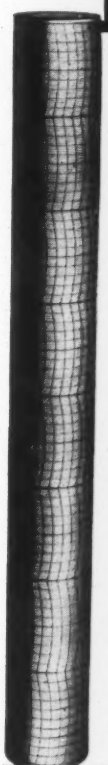
BALDWIN·LIMA·HAMILTON
Electronics & Instrumentation Division
Waltham, Mass.
SR-4® Strain Gages • Transducers • Testing Machines

CIRCLE 158 ON READER-SERVICE CARD





GUBELMAN CHARTS INCORPORATED EST 1893



CHARTS

for Recording Instruments

We offer to the Instrument Maker Charts for all methods of Recording: Pen, Ball Point, Electrical, Thermal, Pressure and Metallic Stylus.

Precise quality control of materials, modern specialized equipment operated under controlled atmospheric humidity conditions by highly skilled and experienced personnel combine to produce Charts of uniformly high accuracy.

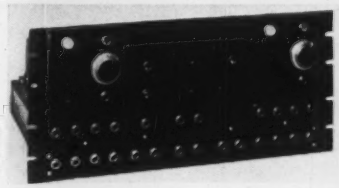
GUBELMAN
CHARTS INCORPORATED
100-6 E. KINNEY ST., NEWARK 5, N. J.

and is accurate to ±2% of range. The hydrogen insensitivity makes the unit particularly well suited for O_2 measurement in inert gas atmospheres, petroleum processes, and other high-hydrocarbon mixtures.—2-page Bulletin 59-B632 gives details.—*Hays Corp., Michigan City, Ind.*

CIRCLE 284 ON READER-SERVICE CARD

PROBABILITY DISTRIBUTION ANALYZER

New Probability Distribution Analyzer, Model PDA 675F, is an electronic instrument for use in simulation studies of control systems and processes that include random variables. The PDA enables measurement

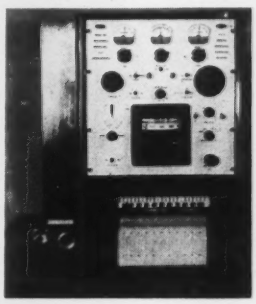


of the amplitude distribution of any random variable with a high statistical confidence level. It also measures the joint probability of either two successes or a success and a failure, coincident for two different variables. Sampling pulses, with internal trigger are 1.5 to 40 kc repetition rate; with external trigger.—10 cps to 40 kc.—*GPS Instrument Co., Inc.* 180 *Needham St., Newton* 64, *Mass.*

CIRCLE 285 ON READER-SERVICE CARD

GAS CHROMATOGRAPH

New Model 202 Linear Programmed Temperature Gas Chromatograph performs gas analyses by the gas-solid technique. In the linear programming technique, the column temperature is linearly increased during



a run, whereby separate well-defined sharp peaks can be observed. Features include high speed (7 min to heat the column from 40° to 400°C, and 7 minutes to cool back to 40°C), and short time required to remove the column, add a new column, sweep the air from the new column, and achieve baseline stability (6 min.).—*F&M Scientific Corp.*, 1001 *Kendall Rd., Wilmington* 5, *Del.*

CIRCLE 286 ON READER-SERVICE CARD

- Small size
- Reduced cost
- Long life
- Friction reduction
- Corrosion resistance
- Dry operation
- Non-magnetic material

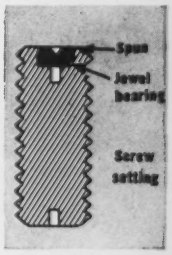
BIG REASONS WHY

Bird PRECISION JEWEL BEARINGS MEAN BETTER INSTRUMENT PERFORMANCE

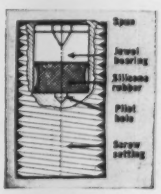
In today's miniaturized instrumentation Bird Sapphire and Glass Jewel Bearings show their unique properties to best advantage . . . dry operation through temperature extremes . . . resistance to corrosion fumes and liquids . . . adaptability to special mounting arrangements.

Bird Complete Jewel Assemblies

. . . save time and money, cut rejects, keep production flowing smoothly. Special mounting techniques provide assemblies in screws or bushings of any style.



Bird Cushion Jewel Assemblies



. . . add shock protection to any instrument for only pennies. Variable cushioning of silicone rubber controls movement, eliminates waste due to poor bearing adjustment in mounting.

Compared with other types of bearings Bird Jewels are substantially more economical and their long life expectancy eliminates maintenance problems.

NEW CATALOG AVAILABLE

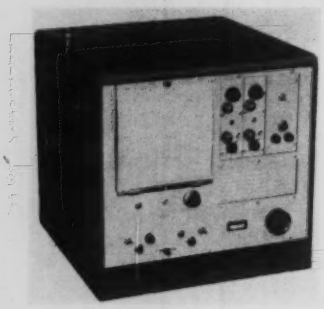
. . . a complete description of properties and uses of jewel bearings for aircraft, electrical and timing instruments, recorders and indicators. Write for your copy.

Richard H. Bird & CO., INC.
1 Spruce Street, Waltham, Mass.

CIRCLE 160 ON READER-SERVICE CARD

X-Y RECORDER

New Model 670 X-Y Recorder which uses optical galvanometers, a light beam trace and immediate-developing direct print paper charts makes possible fast, accurate recording of families of transistor curves, or of rapid



mechanical displacement, velocity, and acceleration. Traces are made by an ultraviolet light beam on 8" x 8" charts. Writing speeds in excess of 2500"/sec may be attained. Over-all frequency response is 3 db down at 130 cps and is independent of amplitude. Linearity is 1% of full scale; sensitivity, is 62.5 μv/in.—*Sanborn Co., Industrial Div., 175 Wyman St., Waltham 54, Mass.*

CIRCLE 287 ON READER-SERVICE CARD

PORTABLE E-I-R METER

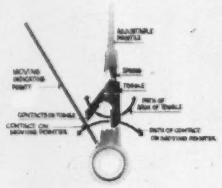
New battery-powered portable E-I-R, meter, Model 110A, has transistorized circuitry designed to measure d-c voltage, current, and resistance. Voltage range is 1 mv to 1000 v

full scale in 13 ranges; input resistance is 101 Mohms. 18 current ranges provide measurement of full scale values from 1 mva to 300 ma; voltage drop for all ranges is 100 mv. Direct-reading resistance scales indicate from 10 ohms to 100 megohms, center scale. Accuracy of indication is ±2% of full scale for voltage and current measurements, and ±4% midscale for resistance.—*Belleville-Hexem Corp., 638 University Ave., Los Gatos, Calif.*

CIRCLE 288 ON READER-SERVICE CARD

CONTINUOUS-READING METER RELAYS

New CR (Continuous Reading) locking-contact Meter-relays feature new design principle in which the moving pointer shows the signal level at all times, even when the set point



has been passed and control circuits have been energized. The circuits remain operative until reset calls for opposite action. Key to the new design is a V-shaped toggle, with contacts on each of its arms. When the indicating pointer reaches set point, a contact on the pointer touches a contact on the toggle and a circuit is closed through both a booster coil and the coil of a multi-pole load relay. The load relay initiates the desired control action, while by snap-action of the toggle the indicating pointer can freely pass the set point. A similar action takes place in the down-scale movement past the set point.—*Assembly Products, Inc., 75 Wilson Mills Rd., Chesterland, Ohio.*

CIRCLE 289 ON READER-SERVICE CARD

CREATING ENVIRONMENT

- HOT
- COLD
- HUMIDITY

AT LOW COST

USES DRY ICE FOR LOW TEMPERATURES AND NICHROME WIRE HEATERS FOR HIGH TEMPERATURES.

From Minus 90° F to Plus 240° F

2 x 2 x 2 Vertical Laboratory Model

DEVELCO

DEVELOPMENT ENGINEERING COMPANY, INC.

9 Cross Street • Norwalk, Connecticut

• *Manufacturers of Environmental Test Equipment*
Fungus - Cold - Heat - Altitude - Humidity - Salt Spray

CIRCLE 161 ON READER-SERVICE CARD

OPTICS

A. D. JONES OPTICAL WORKS

2400 MASSACHUSETTS AVENUE
CAMBRIDGE 40 MASSACHUSETTS
TRowbridge 6-3368—3369

A LIST OF MATERIALS WE FABRICATE USED IN OPTICS AND ELECTRONICS

SAWING GRINDING POLISHING DRILLING

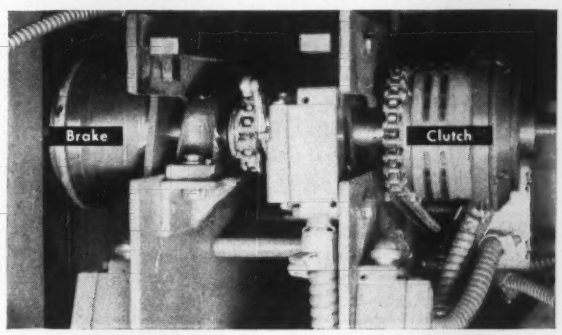
ALUM
ALUMINA
ALUMINUM
ANTHRACENE
ARSENIC TRISULPHIDE
BARIUM TITANATE
BISMUTH
BRASS
CARBORUNDUM
CERAMIC
COBOLT FERRITE
COPPER
*CORNING 707
*CORNING 7052
CUPROUS BROMIDE
FERRITE
FERROX
**FLUORIDE, CALCIUM
**FLUORIDE, LITHIUM
GALLIUM ANTIMONIDE
GALLIUM ARSENIDE
GARNET
GERMANIUM
GOLD
INDIUM ANTIMONITE
INDIUM PHOSPHIDE
INDOX
IRON SINGLE CRYSTAL
LITHIUM FERRITE
MAGNETIC PLUMBITE
MELAMINE FIBER GLASS
MICA, SYNTHETIC
NICKEL OXIDE
PLATINUM
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
**SAPPHIRE
**SODIUM CHLORIDE
**STEEL
STRONTIUM TITANATE
TEFLON
TITANIUM DIOXIDE
*VYCOR
*X-RAY LEAD GLASS
ALL TYPES KNOWN GLASS

* Carried in stock
** Purchased for orders

CIRCLE 162 ON READER-SERVICE CARD

Simplatrol

LARGER SIZES ELECTRIC CLUTCHES & BRAKES



Give swift, certain push-button control on automatic die cutting press.

Here you see Simplatrol 130 Electric Clutch and Brake units installed in a high speed, automatic die cutting press.

These durable Simplatrol units control the vital and unique automatic table drive motion in the press. Clutch and brake actions are timed and controlled by photoelectric cell.

Simplatrol's patented diaphragm feature means reduced maintenance cost in this and in hundreds of other installations. There is no shock or noise in the clutching and braking action.

Ask for complete Simplatrol literature.

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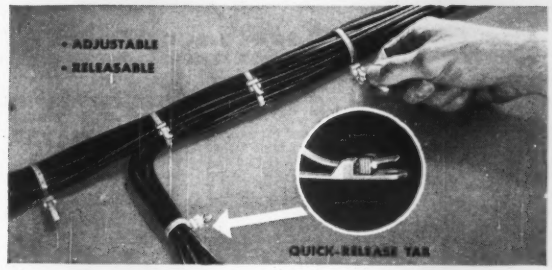
24-8 SALISBURY ST., WORCESTER, MASS.
Representation in Key Industrial Areas

116-9

CIRCLE 163 ON READER-SERVICE CARD

NEW PANDUIT LOK-STRAP®
Nylon Cable Clamps and Ties



Speed production . . . reduce assembly, inventory and revision costs . . . specify Panduit "Lok-Straps" for *all* wiring harnesses from $\frac{1}{8}$" to $1\frac{3}{4}$" in diameter. Only one size replaces a complete range of sizes of conventional cable clamps. "Lok-Straps" can be installed and released by hand . . . opened and closed repeatedly for tracing and revision *without damage, without special tools!*

Panduit "Lok-Strap" Cable Clamps and Ties both employ the same efficient quick-release tab and rugged construction—precision molded Nylon, with excellent insulating properties, high tensile strength and a service temperature range from —65°F. to +350°F. They resist an unlocking force of 80 lbs., yet release with *only ounces* of fingertip pressure.

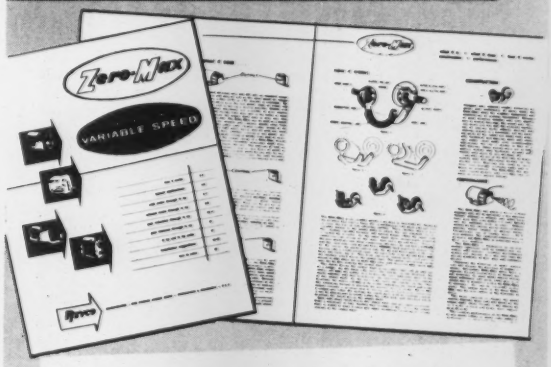
Get complete information now! Write for descriptive Bulletin and sample.

See Our Display—Wescon Show Booth 921

PANDUIT CORP. 14461 WAVERLY AVENUE
Dept. T, MIDLOTHIAN, ILL.

CIRCLE 164 ON READER-SERVICE CARD

VARIABLE SPEED CATALOG...



Principle and application of low cost stepless **VARIABLE SPEED** drives

This illustrated and diagrammed book shows how to get infinitely variable speed from zero to 2,000 RPM from your fractional horsepower motors. Explains clutching, reversing, instant control, constant torque, presetting RPM's, remote control, measuring torque . . . also models and variations of Zero-Max variable speed drives available.

WRITE FOR YOUR FREE COPY NOW!

THE ZERO-MAX COMPANY ZERO-MAX

Subsidiary of Revco Inc.
1908 Lyndale Ave. S., Minneapolis 5, Minn.

CIRCLE 165 ON READER-SERVICE CARD

H-O-H
THE New WAY TO BUY
GLUCOSATES*
For unsurpassed control of Scale and Corrosion in your plant.
Now even more economical and more effective!
Investigate the application of the Glucosates* to problems in your water using equipment.
Write for booklet on your company letterhead.
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ANALYSTS · CONSULTANTS · MANUFACTURERS
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San Antonio 21, Texas
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CIRCLE 166 ON READER-SERVICE CARD

USE dekatron®

COUNTING TUBES FOR RELIABLE, HIGH SPEED COUNTING APPLICATIONS

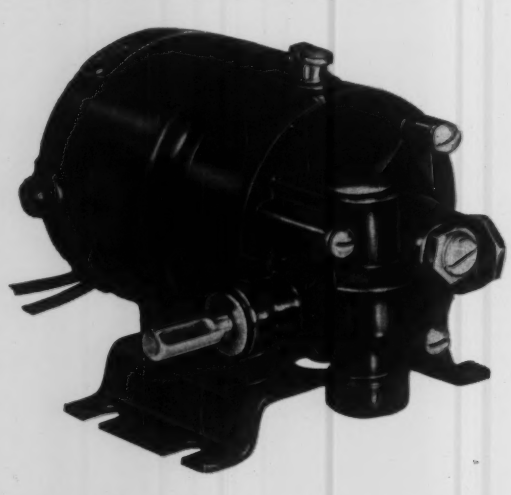
Baird-Atomic uses DEKATRON glow transfer tubes in all instruments where counting and read-out are required. A typical application is the Atomic Instrument Line's Model 134 Scaler for ultra-high speed counting of beta and gamma radioactivity . . . up to 1,000,000 counts/minute! The input circuit incorporates a fast, constant-sensitivity Schmitt discriminator driving a beam switching decade with glow tube read-out . . . 6 DEKATRONS.

You too, can count on DEKATRON for reliable performance. For detailed information request Data Sheet IC 4001.

Baird-Atomic, Inc.
33 UNIVERSITY RD., CAMBRIDGE 38, MASS

Instrumentation for Better Analysis

CIRCLE 167 ON READER-SERVICE CARD



THIS MOTOR . . . as well as thousands of other geared and non-geared electric motors from .65 to 10,000 RPM and from 1/2000 to 50 HP are listed in our latest ready reference stock list file. All items are priced for immediate delivery from our extensive inventory. Also carried in stock and ready for immediate delivery are Heller Thyratron Controllers, Ebert Mercury Relays, Selenium and Silicon Rectifiers, HGB Controllers, Ther Power Supplies. For your free copy of this stock list file — write or call today . . . no obligation and remember we not only give complete information but we give prices as well. **B & B ELECTRIC MOTOR COMPANY,** 206 Lafayette Street, New York, N. Y., WOrth 6-5777.

CIRCLE 168 ON READER-SERVICE CARD

new plants and mergers

INFORMATION SYSTEMS, INC. is a new affiliate of **PANELLIT, INC.** The new company is taking over all operations previously conducted by Panascan and Systems Engineering Divisions.

KEARFOTT CO. has expanded its plant facilities in Asheville, N. C. to a total of 82,500 sq ft.

CROSS-MALAKER LABS. in Mountainside, N. J. is a new wholly-owned subsidiary of The Cross Co., Detroit, founded after the latter has acquired the firm of Stephen F. Malaker Associates.

INDUSTRIAL INSTRUMENTS, INC. has completed two new additions to the plant in Cedar Grove, N. J.

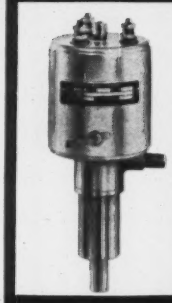
EPSCO, INCORPORATED has completed its move to new facilities in the former General Radio Building.

UNITED ELECTRODYNAMICS has acquired the Electronics Division of the Rheem Manufacturing Co. with the exception of plant and real estate.

NEW HERMES ENGRAVING MACHINE CORP. and its subsidiary **HERMES PLASTICS, INC.** have moved to a larger factory at 154 West 14th St., New York 11.

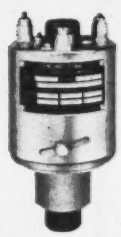
SPEED SENSITIVE SWITCH GOVERNORS

Adjustable within a speed range while running



1 Switch UNDERSPEED OR OVERSPEED

2 Switches UNDERSPEED AND OVERSPEED



3 Switches UNDERSPEED, INTERMEDIATE AND OVERSPEED

All "STANDARD" Speed Sensitive Switches can be furnished to TRIP at any speed between 500 and 6000 RPM. On special order higher or lower speed operation can be supplied. Also special body styles, mounting pads, drives, terminal connectors and caps are available.

Write for Bulletin 504 for further information

SYNCHRO-START PRODUCTS
Since 1932
8151 NORTH RIDGEWAY AVENUE • SKOKIE, ILLINOIS

CIRCLE 169 ON READER-SERVICE CARD

people in the news

C. R. Cary

D. H. Schultz

G. E. Beggs

R. H. Callahan

J. D. Weber

H. B. Lewis

LEEDS & NORTHRUP announces that *C. Reed Cary* has been named board chairman; *Daniel H. Schultz* has become senior vice president; and *George E. Beggs, Jr.* has been elected executive vice president and a director.

EPSCO, INCORPORATED has appointed *Roy H. Callahan* (R.A., U.S. Naval Res., ret.) director of operations; *Bruce K. Smith* assistant to the president—advanced product technology; and *Elton Sherman* and *Jack Haughey* manager and assistant manager, respectively, of the newly-created Standard Systems Dept.

SWARTWOUT CO. has elected *John D. Weber* a vice president and has named him manager of the AutroniC Control Division.

CONSOLIDATED ELECTRODYNAMICS announces appointment of *Howard B. Lewis* as chief engineer of the Transducer Division, and of *Donald E. Stocking* as eastern regional manager.

ELECTRONICS INSTRUMENT CO.'s (EICO) president *Harry R. Ashley*, **FARRIS ENGINEERING CORP.'s** president *Victor W. Farris*, and **NORTH SHORE NAME-**

H. R. Ashley

E. T. Turney

PLATE's president *Eugene T. Turney, Jr.* were among eleven men who recently were honored by Free Enterprize Awards Association's American Success Story Awards for their achievements.

CHASSIS-TRAK, INC. has named *Lawrence M. Vaughn* sales manager.

BOOTH 817—ISA SHOW

DURANT

DIGITAL READ-OUT COUNTERS

for MISSILE TRACKING, RADAR CONTROLS, COMPUTERS, NAVIGATION INSTRUMENTS, GAUGING INSTRUMENTS, and ANY other indicator applications.

- Meets military specifications.
- High speeds, lower torque, lower moment of inertia for long life.
- Nylon wheels with legible figures, nylatron pinions.
- Single, 1½, or double wheels.
- Right or left hand drive, clockwise or anti-clockwise rotation.
- One-piece aluminum die cast frame.
- Base mounting. Threaded mounting holes may be placed in frame top or ends.
- "Y" Series, single or dual bank.
- Component parts can be purchased separately to meet design requirements.

Your answer to an infinite number of variable demands for PRECISION CONTROLS.

Send for Catalog No. 400

DURANT MANUFACTURING COMPANY

1914 N. Buffum St., Milwaukee 1, Wis. • 14 Thurbers Ave., Providence 5, R. I.

REPRESENTATIVES IN ALL PRINCIPAL CITIES

CIRCLE 170 ON READER-SERVICE CARD

END THERMOCOUPLE FAILURES NOW!

new welding technique insures longer life of MgO insulated elements

RECENT LABORATORY TESTS HAVE PROVEN THESE FACTS:

- Resists high thermal shock.
- Eliminates voids between insulation and closure.
- Withstands high temperature, high pressure and intense vibration.
- All closures are welded in inert gas atmosphere.
- Leakproof in liquids and liquid sodium applications.

SUPER-TEMP THERMOCOUPLES AND REPLACEMENT ELEMENTS OFFER ADDITIONAL FEATURES:

- Dense pack insulation.
- Fully annealed sheath allowing excellent forming characteristics.
- High dielectric strength.
- Special select grade of wire used at all times to insure accuracy.
- Delivery from stock.

NOW fulfilling a requirement in the industrial field for a Thermocouple of the highest quality

DETAILS OF COMPLETE LINE AVAILABLE – WRITE . . .

THERMO-COUPLE PRODUCTS CO. INC.

729 NORTH ADDISON AVE. • VILLA PARK, ILL.

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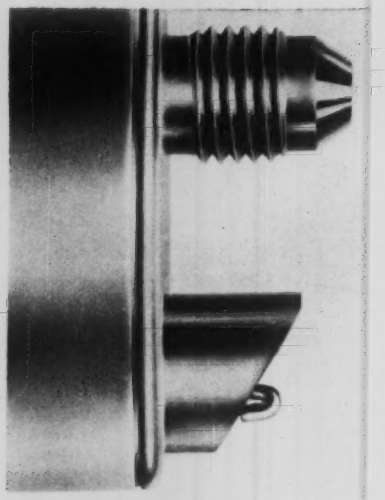
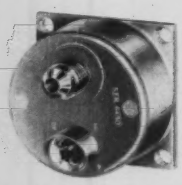




new Bourns absolute pressure transducer

Miniature potentiometer transducer/35G vibration, 20-2000 cps/High accuracy/ 5-ounce weight

New bourdon tube instrument for telemetering and control of missile, pneumatic, and hydraulic systems. Absolute, gage, or differential pressure ranges available with static error band of ±0.9%. Excellent noise-free low error performance in high vibration and acceleration environments.

Model	725
Pressure ranges	up to 0-5000 psia
Static error band*	±0.9%
Dynamic error band (includes ±35G to 2000 cps)	±1.8%
Discontinuities (noise)	None
Size (exclusive of fittings)	1-¾" D x ⅞"

*Includes friction, hysteresis, linearity, resolution, repeatability

Write for complete technical data

BOURNS, Inc.
P.O. Box 2112M, Riverside, Calif.
Field Engineering Offices:
L. I., New York, and Dallas, Texas

Pioneers in potentiometer transducers for position, pressure and acceleration. Exclusive manufacturers of Trimpot®, Trimit®

CIRCLE 172 ON READER-SERVICE CARD

new literature

CONTROL SYSTEMS

PHOTOELECTRIC CONTROLS. 18-page Bulletin GEA-6822 describes line of controls for counting, sorting, signaling, protecting, diverting, detecting, or limiting.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 290 ON READER-SERVICE CARD

VISCOSITY CONTROL SYSTEM. 4-page Bulletin No. V-1224 describes viscosity control equipment for automatic addition of solvent to correct for evaporation losses.—Norcross Corp., 247 Newtonville Ave., Newton 58, Mass.

CIRCLE 291 ON READER-SERVICE CARD

GAMMA RADIATION CONTROL SYSTEMS. 6-page Bulletin 105-C describes the operating principles, performance, and advantages of Ohmart gamma radiation measuring systems for density or specific gravity, and liquid level control.—Ohmart Corp., 2236 Bogen St., Cincinnati 22, Ohio.

CIRCLE 292 ON READER-SERVICE CARD

VALVES

LUBRICATED SPHERICAL VALVES. 12-page Bulletin V-607 Rev. 1 contains descriptions, dimensional drawings, and specifications of 16" to 30" mechanically- and hydraulically-operated hypresphere valves and actuators.—Rockwell Mfg. Co., 400 Lexington Ave., Pittsburgh 8, Pa.

CIRCLE 293 ON READER-SERVICE CARD

PULP AND PAPER VALVES. 16-page Bulletin MD-1 contains application data on control valves, pulp stock valves, Saunders valves, butterfly valves, pressure and liquid level transmitters, etc., in pulp and paper making processes.—Conoflow Corp., Dept. D-8, 2100 Arch St., Phila. 3, Pa.

CIRCLE 294 ON READER-SERVICE CARD

CONTROL VALVES. 8-page Bulletin J-170 describes sliding-gate and plate control valves with application information, dimensional drawings, flow capacities, rating charts, flow curve, and sample specifications.—OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio.

CIRCLE 295 ON READER-SERVICE CARD

TEMPERATURE

TEMPERATURE TRANSMITTER. 4-page Product Specification P51-4 discusses details of a helium gas-filled system for temperature measurement and pneumatic transmission.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

CIRCLE 296 ON READER-SERVICE CARD

TEMPERATURE LOGGING. 2-page Bulletin 350-1 details full specs and data of temperature scanning and logging system.—Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

CIRCLE 297 ON READER-SERVICE CARD

THERMISTOR CONTROLLER. 2-page Bulletin MC-179 describes the transistorized thermistor controller, Series 535.—Fenwal Inc., Pleasant St., Ashland, Mass.

CIRCLE 298 ON READER-SERVICE CARD

SIGNALING CONTROLLER. 4-page catalog describes and lists specs for potentiometer-type signaling controller.—Thermo Electric Co., Inc., Saddle Brook, N. J.

CIRCLE 299 ON READER-SERVICE CARD

THERMOCOUPLES. 4-page Bulletin 3A contains tabulations of specs, and sketches of connections and heads for Trinox thermocouples.—Trinity Equipment Corp., Cortland, N. Y.

CIRCLE 300 ON READER-SERVICE CARD

ENVIRONMENTAL CHAMBERS. 4-page Catalog 102 illustrates and describes temperature-humidity chambers.—Harris Refrigeration Co., 308 River St., Cambridge 39, Mass.

CIRCLE 301 ON READER-SERVICE CARD

RADIATION PYROMETER. Catalog 105 gives information on Pyro radiation pyrometer. Includes technical information on the principles of radiation pyrometry.—Pyrometer Instrument Co., Bergenfield, N. J.

CIRCLE 302 ON READER-SERVICE CARD

BIMETAL THERMOSTATS. 4-page Bulletin 8400 gives condensed technical data, operating ranges, ratings, etc. of bimetal thermostats.—Stevens Mfg. Co., Inc., P.O. Box 1007, Mansfield, Ohio.

CIRCLE 303 ON READER-SERVICE CARD

THERMISTOR PROBES. 6-page brochure contains information on Thermistemp thermistor probes with resistance chart, descriptive tabulation, and probe information.—Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio.

CIRCLE 304 ON READER-SERVICE CARD

PRESSURE, WEIGHT

DRAFT GAGES. Three bulletins, 59-B211 (2 pages), 59-B212 (4 pages), and 59-B213 (2 pages) contain information about pointer and indicator gages for low pressure, draft, or differential pressure measurements.—Hays Corp., Michigan City 39, Ind.

CIRCLE 305 ON READER-SERVICE CARD

PRESSURE MEASUREMENT. 4-page Bulletin 3018 describes systems for calibration-benches, wind tunnel pressure measurement, liquid level control, determination of pressure ratios, calibration of pressure switches, aneroid barometers, pressure pickups, etc.—Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

CIRCLE 306 ON READER-SERVICE CARD

PRESSURE TRANSMITTERS. 4-page Bulletin MDSP 592-16 lists aircraft synchro pressure transmitters and indicators, also flow indicators, and pressure switches with specifications.—Bendix Aviation Corp., Montrose Div., South Montrose, Penna.

CIRCLE 307 ON READER-SERVICE CARD

PRESSURE GAGES. 4-page Brochure 500SF describes new line of solid-

front pressure indicating and test gages.—Crosby Valve & Gage Co., Wrentham, Mass.

CIRCLE 308 ON READER-SERVICE CARD

MULTIPLE PRESSURE READOUT. 12-page Catalog 30B1000 describes the multiple pressure readout system which uses a single high-accuracy transducer.—Fischer & Porter Co., 225 Jacksonville Rd., Hatboro, Penna.

CIRCLE 309 ON READER-SERVICE CARD

WEIGHING SYSTEMS. 8-page Bulletin 591 covers Way-Pac 5000-series weighing system with five basic types of cells.—A. H. Emery Co., Pine St., New Canaan, Conn.

CIRCLE 310 ON READER-SERVICE CARD

GAGE SYPHON AND SNUBBER. 2-page Bulletin 101 describes and explains uses of Type 6 combined pulsation absorber, seal pot, and steam syphon.—Defender Instrument & Regulator Co., Boody, Ill.

CIRCLE 311 ON READER-SERVICE CARD

FLOW, LEVEL

SMALL-FLOW ROTAMETERS. 4-page Bulletin 18P describes line of purge rotameters for measuring and controlling fluids flowing at low rates.—Schutte and Koerting Co., Instrument Div., Dept. M-P, Cornwells Heights, Bucks County, Penna.

CIRCLE 312 ON READER-SERVICE CARD

PLASTIC DALL FLOWTUBES. 4-page Bulletin 115.20-1 describes expanded line of insert-type plastic dall flow tubes for primary flow metering. The line now includes thirteen tube sizes between 4" and 48" as stocked items.—B-I-F Industries, Inc., 345 Harris Ave., Providence, R. I.

CIRCLE 313 ON READER-SERVICE CARD

LEVEL/INTERFACE CONTROLS. 8-page pamphlet describes Liquisonic Controls with ultrasonic design for level and interface control of liquids, solids, and slurries.—Meter Service and Supply Co., P.O. Box 2373, 2127 Kermit Hiway, Odessa, Tex.

CIRCLE 314 ON READER-SERVICE CARD

COUNT, TIME

COUNTING INSTRUMENTS. Catalog and Price List Form AD 341 describes electric counting instruments.—PIC Automation Controls Div., General Controls Co., 8062B McCormick Blvd., Skokie, Ill.

CIRCLE 315 ON READER-SERVICE CARD

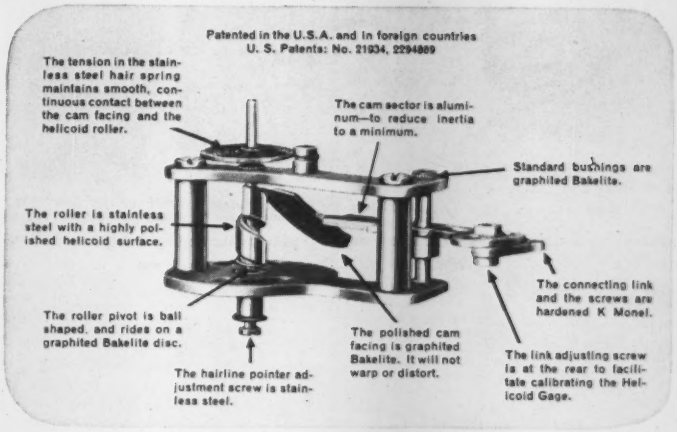
TIMING DEVICES. 4-page Bulletin BX 265 describes timers, time switches, time delay relays, etc., and facilities for their manufacture.—M. H. Rhodes, Inc., 30 Bartholomew Ave., Hartford 6, Conn.

CIRCLE 316 ON READER-SERVICE CARD

IMPULSE COUNTERS. 4-page condensed catalog illustrates, describes and specifies nine impulse counting devices made in Switzerland.—Landis & Gyr, Inc., 45 W. 45th St., New York 36, N.Y.

CIRCLE 317 ON READER-SERVICE CARD

ACCO Helicoid Gage U.S.A.


Patented in the U.S.A. and in foreign countries
U. S. Patents: No. 21934, 2294889
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is aluminum—to reduce inertia to a minimum.
Standard bushings are graphited Bakelite.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides... *Sustained Accuracy*... on the toughest jobs

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details **Ask for Catalog DN-65**

HELICOID GAGES

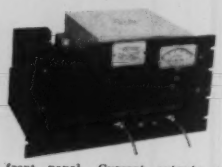
ACCO

Helicoid Gage Division • American Chain & Cable Company, Inc.

929-B Connecticut Ave., Bridgeport 2, Conn.

CIRCLE 173 ON READER-SERVICE CARD

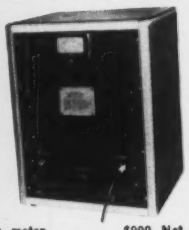
SPELLMAN HIGH VOLTAGE POWER SUPPLIES



MODEL PN-30R REVERSIBLE POLARITY

Continuously Variable 1-30KV Unregulated DC Power Supply in wide use for insulation testing, precipitators and laboratory research. Polarity reversible from front panel. Current output: approx. 2 ma. at 20KV; 250 microamperes at 30KV. Input: 110V AC 60 cycles .....$225 Net

With Meter .....$275 Net

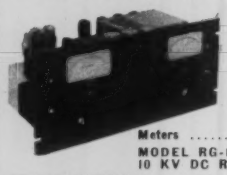


MODEL LAB-90 RF TYPE CONTINUOUSLY VARIABLE 0-90 KV REGULATED DC POWER SUPPLY

Output current .7 ma. at 90 KV; 1 ma. at 80 KV; 2 ma. from 40 KV down. Regulations better than 1% throughout entire range. Dimensions: 28" high, 21 ¾" wide, 18" deep

LAB-90 Complete with meter .....$900 Net

Specify polarity output—positive or negative.



MODEL RG-5 5 KV DC REGULATED POWER SUPPLY

Output current 2 ma. Regulated against line and load 1%. Variable 3 to 7 KV. Complete with Meters .....$250 Net

MODEL RG-10 10 KV DC REGULATED POWER SUPPLY

Output current 2 ma. Regulated against line and load 1%. Variable 7 to 12 KV.

Complete with Meters .....$260 Net

MODEL RG-15 15 KV DC REGULATED POWER SUPPLY

Output current 2 ma. Regulated against line and load 1%. Variable 12 to 17 KV.

Complete with Meters .....$275 Net

MODEL 4575 5 KV—1 ma. DC POWER SUPPLY

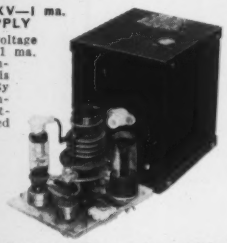
For an output voltage of 5 KV DC at 1 ma. the low voltage input requirement is 250V at 50 ma. By varying the DC input the output voltage can be varied from approx. 1 KV to 7½ KV.

MODEL 4575 .....$32.50 Net

MODEL 4575-2 Same as above with 2 ma. Output at 5 KV .....$42.50 Net

MODEL 4575PN Same as 4575 except reversible polarity .....$42.50 Net

MODEL 4575-2 PN Same as 4575-2 except reversible polarity .....$52.50 Net



COMPLETE LINE OF HIGH VOLTAGE COILS—Send for complete catalog IC

SPELLMAN HIGH VOLTAGE CO. FORMERLY SPELLMAN TELEVISION CO., INC.

3029 WEBSTER AVE. BRONX, 67, N. Y. Kingsbridge 7-0306

CIRCLE 174 ON READER-SERVICE CARD

JOHN WORLEY JEWEL COMPANY 1900

JEWEL BEARINGS and TUNGSTEN CARBIDE BEARINGS and ORIFICES in Sizes under 1/4" O. D.

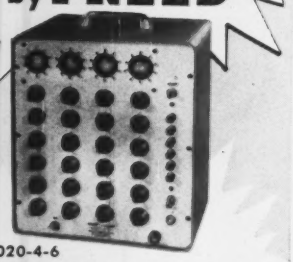
We specialize in instrument bearing design problems and production of pilot lots in our own plant in the U.S.A. We also offer top quality Swiss imports at low production prices.

JOHN WORLEY JEWEL CO.

No. Falmouth, Massachusetts

CIRCLE 175 ON READER-SERVICE CARD

NEW!! MULTIPLE PRESET COUNTER by FREED



TYPE 2020-4-6

The Freed Type 2020-4-6 Multiple Preset Counter was designed for sequential predetermining control and is ideally suited for applications when a machine or a process is started manually and stops automatically at several preset counts in one operation. One of the applications for this counter is the winding of tapped toroidal or transformer coils.

Premium components, simplified circuits, using a minimum of computer type vacuum tubes and a silicon diode power supply provides reliable maintenance free operation.

SPECIFICATIONS

- MAXIMUM COUNT: 4 digits 9,999
- COUNTING RATE: 4000 per second
- PRESETS: 1-6
- INPUT: Photocell, Switch closure, Pulse
- OUTPUT: Relay DPDT — 5 Amp contacts
- SIZE: 11 x 13 x 8⅝ inches
- WEIGHT: 19½ lbs.
- POWER SUPPLY: 105-125 Volts—50-60 cycles

Freed also manufactures Preset, Totalizing, Batching and Timing counters.

Send for complete information.

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TIME AND EVENT RECORDERS. 8-page brochure presents line of modular time and event recorders, including alphanumeric printers and digital readout systems.—American Data Division, American Electronics, Inc., 75 Front St., Brooklyn 1, N. Y.

CIRCLE 318 ON READER-SERVICE CARD

VELOCITY, VIBRATION

LINEAR VELOCITY TRANSDUCER. 4-page bulletin gives details on operating principle and features of LVsyn linear velocity transducers.—Sanborn Co., 175 Wyman St., Waltham 54, Mass.

CIRCLE 319 ON READER-SERVICE CARD

SHOCK AND VIBRATION. 48-page spiral binder contains information on accelerometers, cathode followers, amplifiers, and instrumentation systems.—Columbia Research Labs., MacDade Blvd. and Bullens Lane, Woodlyn, Penna.

CIRCLE 320 ON READER-SERVICE CARD

DATA HANDLING

DATA PROCESSING. 4-page Bulletin IL 917 contains illustrations, descriptions, and specs of standard data-processing instruments, including plotters, function generators, voltmeters, printers and converters.—Electronic Associates, Inc., Long Branch, N. J.

CIRCLE 321 ON READER-SERVICE CARD

MAGNETIC TAPE TRANSPORT. 4-page Bulletin 3215 describes Model 546 magnetic tape transport.—Burroughs Corp., ElectroData Div., 460 Sierra Madre Villa, Pasadena, Calif.

CIRCLE 322 ON READER-SERVICE CARD

DIGITAL COMPUTER. 6-page Bulletin AB-059 describes highlights of the G-15 digital computer, also of Pogo and Intercom 1000 programming systems, etc.—Bendix Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif.

CIRCLE 323 ON READER-SERVICE CARD

AUTOMATIC DATA PROCESSING. 4-page Bulletin CC-220 describes an advanced research, design, and development facility for data processing systems and components.—Franklin Electronics Inc., Communications and Control Div., Van Nuys, Calif.

CIRCLE 324 ON READER-SERVICE CARD

TAPE TRANSPORTS. 12-page Catalog 4-59 contains pictures, descriptions, and specs of transistorized tape transports and accessories.—Potter Instrument Co., Inc., Plainview, N. Y.

CIRCLE 325 ON READER-SERVICE CARD

MAGNETIC HEADS. 8-page brochure describes tape and drum heads.— J. B. Rea Co., Electronics Div., 2202 Broadway, Santa Monica, Calif.

CIRCLE 326 ON READER-SERVICE CARD

RECORDING TAPE BASE. 12-page Booklet A11076 outlines advantages, properties, and characteristics of Mylar as base material for magnetic re-

cording tape used for instrumentation purposes.—Du Pont Co., Film Dept., Wilmington 98, Del.

CIRCLE 327 ON READER-SERVICE CARD

DIGITAL INSTRUMENTATION. 12-page 1959 Comprehensive Catalog illustrates, describes and specifies counter-timers, frequency meters, time-interval meters, printers, voltmeters, decade counters, etc.—Computer Measurements Co., 5528 Vineland Ave., North Hollywood, Calif.

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MONITORS

MONITOR. 2-page Bulletin 5903 describes the "CM" System for monitoring, telemetering and remote control in the water supply field.—Femco, Inc., Irwin, Penna.

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MONITOR. 4-page bulletin describes with pictures and words the Monitron automatic-scanning, alarm and control system.—Moore Associates, Inc., 2600 Spring St., Redwood City, Calif.

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ELECTRICAL,ELECTRONIC INSTRUMENTS

FREQUENCY CONVERTER. 4-page Bulletin 2024 describes Type 2A, a broad range frequency converter for 15 to 40,000 cps inputs.—Cox Instruments Div., George L. Nankervis Co., 15300 Fullerton, Detroit 27, Mich.

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CLOSED-CIRCUIT TV. 8-page Catalog 6-103 contains illustrations, diagrams and complete description of closed-circuit ITV.—Kin Tel Div. of Cohu Electronics, Inc., 5725 Kearny Villa Rd., San Diego 11, Calif.

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MINIATURE POWER PACKS. 2-page Cat. Sheet 116 describes and lists 8 models of miniaturized solid-state power packs with specs and features.—Electronic Research Associates, Inc., 67 Factory Pl., Cedar Grove, N. J.

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CLIP-ON 'SCOPE PROBE. 4-page issue of "H-P Journal," Vol. 10/No. 9-10, describes "a clip-on oscilloscope probe for measuring and viewing current waveforms."—Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.

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SWEEP GENERATORS. 4-page Short-Form Catalog, No. 8-A covers sweep generators and allied equipment.—Telonic Industries, Inc., Beach Grove, Ind.

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DIFFERENTIAL VOLTMETER. 4-page Form 335 describes features and specs of d-c/a-c precision differential voltmeter with direct in-line readout.—John Fluke Mfg. Co., 1111 West Nickerson, Seattle 99, Wash.

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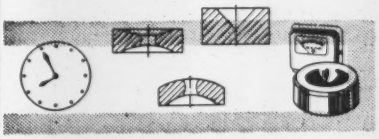

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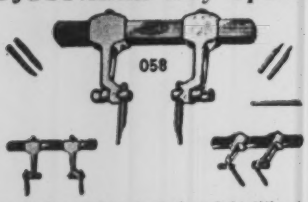

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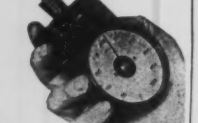

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ELECTROMETERS. 8-page Form 3026-9 outlines general features of electrometer line, and gives detailed specification data.—Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.

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VOLTAGE CALIBRATOR. 2-page leaflet describes and specifies Type 100 voltage calibrator for oscilloscopes, a-c or d-c voltmeters, and measurement types of test equipment.—Exact Electronics, Inc., P.O. Box 552, Portland 7, Ore.

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CORE GRADING INSTRUMENT. 4-page bulletin describes the Permeameter an instrument for grading powdered iron and Mo-permalloy toroidal cores. —Boesch Mfg. Co., Inc., Danbury, Conn.

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RECLOSER TESTER. 8-page Bulletin SB-OCR-1 describes with pictures and specs Arc Current Time Simulator tester (ACTS) for oil circuit reclosers.—Multi-Amp Div., Multi-Amp Electronic Corp., 465 Lehigh Ave., Union, N. J.

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ELECTROLYTIC CAPACITORS. 2-page Bulletin 152D contains details of Series TF tantalum-foil electrolytic capacitors.—Ohmite Mfg. Co., 3634 Howard St., Skokie, Ill.

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MULTI-CONDUCTOR CABLE. Folder contains one 3-page and eight 2-page bulletins illustrating and describing Tape Cable, a flat multi-conductor.—Tape Cable Corp., 790 Linden Ave., Rochester 10, N. Y.

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MISCELLANEOUS

ELECTRONIC TEACHING AIDS. 6-page Folder S-18 describes a new series of educational literature on electrical and electronic measurements for use in college-level and advanced study, as well as industry training programs and schools.—Daystrom-Weston Sales Div., 614 Frelinghuysen Ave., Newark 12, N. J.

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COMPRESSED-AIR FILTERS. 4-page Bulletin 4158 gives descriptions, specifications and cross-sectional line drawings of Model M-30T and M-100T Condensifilters.—Hankison Corp., College & Pike, Canonsburg, Penna.

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AUTOMATIC BEARING CLEANING. 2-page leaflet gives information on automatic bearing cleaning machine. —Bearing Inspection, Inc., 3311 East Gage Ave., Huntington Park, Calif.

CIRCLE 350 ON READER-SERVICE CARD

BELLOWS SEALS. 20-page Bulletin No. BF200-3 presents basic description of Bellofram seals with typical applications and uses.—Bellofram Corp., Blanchard Rd., Burlington, Mass.

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CYANIDE ANALYSIS. 2-page leaflet reviews continuous determination of cyanide concentration in liquids or gases with AutoAnalyzer continuous automatic chemical analysis equipment.—Technicon Controls, Inc., Chauncey, N. Y.

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RADIOISOTOPES. 4-page brochure explains how radioisotopes provide optimum quality control in continuous process operations.—Radiation Counter Laboratories, Inc., Nucleonic Park, Skokie, Ill.

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FLOATING FLOORS FOR COMPUTER ROOMS. 8-page bulletin describes with photographs actual installations of floating floors in computer and data processing rooms.—Floating Floors, Inc., 22 East 42nd St., New York 17, N. Y.

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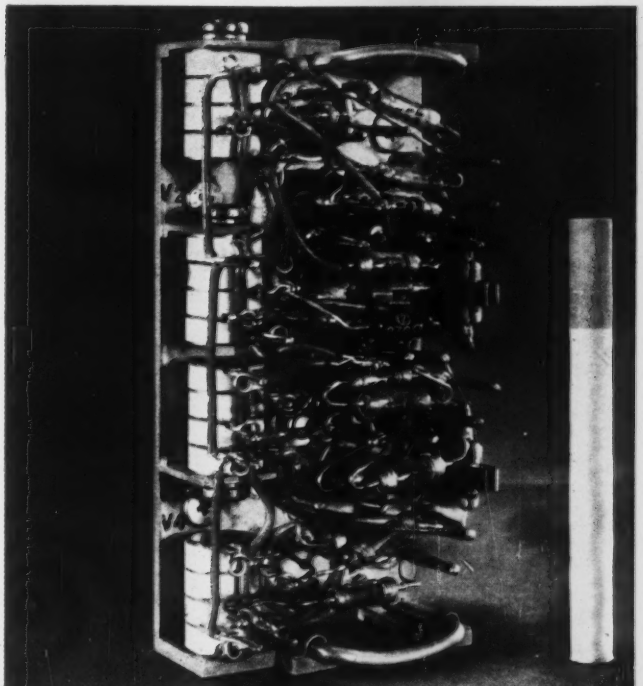
CIRCLE 364 ON READER-SERVICE CARD

Engineers from many fields EE, ME, Metallurgy, Physics



ELECTRONIC AMPLIFIER ASSEMBLY—to be mounted on aircraft nuclear power plant. Designed to meet these specifications: — 65° F to 600° F and extremely high radiation tolerance.

Exploring New Areas in Controls and Instrumentation for Nuclear Powered Flight

The peculiar characteristics of a reactor as a power source for flight require a new approach to controls system engineering at General Electric's Aircraft Nuclear Propulsion Dept.

Many problems are introduced – not associated with chemically powered engines, for instance:

RADIATION and HIGH TEMPERATURE CONSTRAINTS. For example, electronic sub-systems – such as the Electronic Amplifier Assembly pictured above can operate reliably under high gamma and neutron bombardment and at 600° F. This calls for new materials and new processing techniques – and consequently, new design concepts.

MINIMUM SIZE and MINIMUM WEIGHT commensurate with optimum performance—a requirement of the entire aircraft nuclear propulsion program.

The bulk of the reactor control systems mechanisms and circuitry is developed at the ANP Control System Laboratories. The development of Controls and Instrumentation for a power reactor for aircraft naturally involves direct testing in reactors. Much developmental work is also conducted with analog simulators.

CURRENT OPENINGS FOR:

Electrical Engineers
Physicists
Metallurgists
Mechanical Engineers
Engineering Physicists

AREAS:

1. Development of Nuclear and Temperature Sensors
2. Development of high temperature, radiation resistant electrical and electronic circuitry
3. Systems Analysis and Design of nuclear power plant control systems.

Write in strict confidence, stating salary requirements, to:

Mr. P. W. Christos, Div. 33-MH

AIRCRAFT NUCLEAR PROPULSION DEPT.

GENERAL ELECTRIC

P.O. Box 132, Cincinnati 15, Ohio

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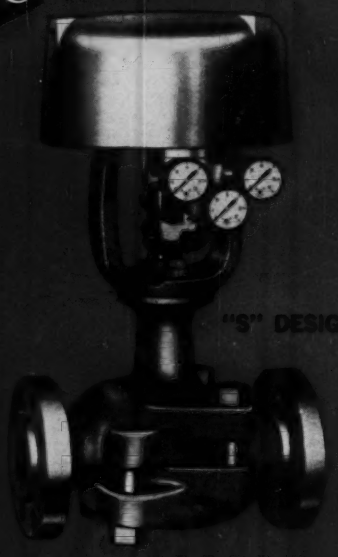
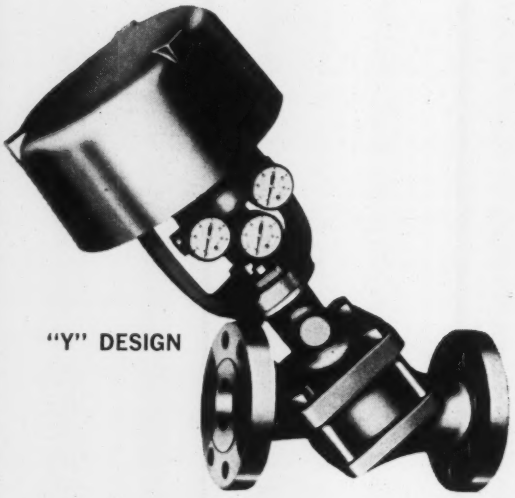
MORE CAPACITY

TWO NEW SPLIT-BODY VALVES



"S" DESIGN



"Y" DESIGN

BEST BY PRESENT AND FUTURE STANDARDS!

This new Hammel-Dahl "S" model starts out traditionally... split-body, I.S.A. standards, slip-on flanges and retained, invertible seat ring... but that's where similarity with other "S" types ends!

Greatest possible flow capacity combines with extended-stem guiding and travel length to give optimum flow control for the most demanding modern process.

Nominal Sizes: ½" to 10"

Body Configurations: "S" and "SL" (90° angle)

Body Ratings: 600 lb. ASA to 2500 lb. ASA

Connections: 150 to 2500 lb. ASA Flanged. (Removable or Integral Flanges.) Screwed or welding ends.

Face-to-Face: I.S.A. Std. Also available in non-standard dimensions.

Materials: Cast Steel, Stainless Steel, Cast Iron, Nodular Iron, or any castable alloy.

YOUR CHOICE OF ACTUATORS: The Positioning Piston (shown) is one of more than 15 easily interchangeable actuator designs. Modes of actuation include:

- Pneumatic (Piston, Diaphragm, Isoforce)
- Electro-Hydraulic (Hydrameter)
- Electric (Tork-Master) or Manual.

The advanced new "Y" design incorporates I.S.A. standard face-to-face* dimensions, "S" valve travels and actuators. But it sets **new standards** for CV per nominal pipe size and for mechanical characteristics of fluid control. Straight-through flow eliminates hold-up and Cv's are **phenomenal** in every size.

Nominal Sizes: ½" to 10"

Body Configurations: "Y" and "YL" (45° angle)

Body Rating: 600 lb. ASA to 2500 lb. ASA

Connections: 150 to 2500 lb. ASA Flanged (Integral Flanges.) Screwed or welding ends.

***Face-to-Face:** I.S.A. Std. thru 4" size. Also available in non-standard dimensions.

Materials: Cast Steel, Stainless Steel, Cast Iron, Nodular Iron, or any castable alloy.

You can reduce costs with one of these new Split-Body designs. It's sure worth checking with the Hammel-Dahl Representative in your area. Call today.

Manufacturers of Control Valves and Allied Equipment

HAMMEL-DAHL DIVISION

GENERAL CONTROLS

Warwick Industrial Park, Warwick, Rhode Island

Representatives in Principal Cities of United States, Canada and Europe

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